FOOD FOR BETTER PERFORMANCE

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Foreword

Another book on food? Yes, but a book with a difference, a book in which the results of recent research on food and diet are presented not only as information of great interest, but with convincing reference to practical application.

Food for Better Performance will appeal to all critical readers who want to gain a clear and thorough insight into scientific findings, and who want to know the meaning of these findings with regard to the various aspects of life—people at work and at play; and it will appeal equally to those readers who are alert enough to ask the pertinent question: How can I make the best possible use of this modern food-knowledge myself?

Dr Hutchinson combines mastery of the scientific background, personal research experience, and a remarkable degree of forthrightness and commonsense. His frank scepticism of food-fadisms and of the many fallacies beloved by the self-styled expert in sport and other physical activities is most commendable—accompanied as it is by a broadness of outlook, lack of dogmatism, and a conception of man not as a machine but as a wonderful, working, living unit.

This book—small, perhaps, in size—is nevertheless a significant contribution to the full appreciation of the true meaning of food. For as the author remarks, 'good dietary standards can improve all human performance'.

It is a publication which deserves to be read widely and which can greatly contribute to that most valuable of all our possessions—national health.

F. Duras

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Introduction

As its principal objective, this book demonstrates the importance of proper eating habits in improving mental and physical performance. The term performance is used in its widest sense, and may be defined as a work achievement involving capacity, training and motivation. Work covers all forms of mental and physical exertion and includes occupational as well as recreative activities.

For many kinds of work, both mental and physical, machines are gradually replacing human labour. In some industries, involved computations can be performed, and large sources of mechanical power utilized, by simply operating switches. This change is most noticeable in the highly industrialized countries but is spreading throughout the world. Such mechanization is generally accompanied by a shortening of the working week allowing more time for recreative activities.

Many recreations demand a considerable expenditure of energy and increasing numbers of people are expending more energy during their leisure than during their working hours. There appears to be a natural tendency for people employed in sedentary types of occupation to participate in physically strenuous pastimes, whereas those employed on heavy manual work have a tendency for less active recreations. These changed conditions call for a new assessment of total energy requirements.

A person, adequately nourished and physically fit, performs muscular work with comparative ease. His endurance is considerable and he recovers with fair rapidity after the completion of a strenuous task. It is now generally recognized that, if a person is adequately nourished,

the consumption of additional or special foods does not improve his performance. On the other hand, where dietary deficiencies exist, there is little doubt that performance is hindered. In many instances, it is necessary to decide what can be done by dietary means to improve the performance of people who are not clearly underfed, or malnourished.

It is not generally recognized that meal frequency can have an important bearing on all aspects of human performance, large meals and long periods between meals being especially undesirable. Inherent in the term frequency is the size of the meal consumed, more frequent meals meaning smaller meals. There is no scientific basis for the belief held by some people that eating between the three main meals is injurious to health, and that the stomach needs intervals during which to rest.

The ideal criteria for the effects of food on performance, or productivity, are those of actual practice under rigidly controlled conditions. The complexity of the operations involved in most industrial tasks, and many sporting events, provide almost insuperable difficulties in any direct attempt to determine the effect of food on performance. A detailed investigation of the actual task or event is seldom practicable, and all that can be done is to study independent components of the work involved, or reproduce a simplified performance in the laboratory.

Even in the laboratory, unless working conditions can be varied in such a way that the evaluation of all responsible factors is possible, the results of any investigation will be of limited value. Difficulties are presented largely because of the artificial atmosphere that is created, the necessity to restrict observations due to the limited availability of subjects, and the heavy expense that is usually involved. For several years the author was engaged on research in this field, and the results of part of this work are included in the following chapters.

Both the work on which a person is employed for his livelihood, and the sport in which he engages for recreation, involve the performance of mental and physical work for which energy is needed, and can only be provided by food. In spite of the extensive use of machines and automation, the performance of work by man is still a fundamental necessity. It is difficult to imagine that it could ever be otherwise. It is important, therefore, to know what kind of foods and dietary patterns are best for mental and physical performance, the amounts of energy necessary for useful work to be performed, and many other related problems.

Mental performance is less tangible than physical. Energy requirements are much smaller and not known with the same accuracy, and there is no satisfactory method of measuring total work output. Performance in terms of accuracy and speed can be measured under certain conditions, but the results are complicated by the fact that all mental tasks improve greatly with practice. Mental performance after long intervals without food, and after the consumption of large amounts of food, has been investigated with interesting results.

To be able to understand and appreciate the importance of an adequate diet for optimum mental and physical performance, an elementary knowledge of nutrition is necessary. This is provided in the following chapter: more detailed information is available in many textbooks, including one by the author.[1] An elementary knowledge of nutrition would be of particular value to those desirous of reaching the weight at which they look, feel and perform best. It would enable them to make food substitutions that could prevent a restricted diet from becoming very monotonous.

It is also important to have at least a superficial know-

[1] *Food for the People of Australia* (Angus and Robertson, Sydney, 1958).

ledge of what happens to food after it enters the digestive tract, and the length of time it is likely to remain there before being absorbed. Large meals can be physically inconvenient to people working in a bent position, and they can restrict breathing, a matter of considerable importance to athletes. They can also affect one's mental attitude towards activitity of any kind. Long periods between meals, which usually precede large meals, have been found to affect one's ability to concentrate.

A striking feature of modern life is that, with food habits guided by the newer knowledge of nutrition, full adult capacity may be reached earlier and retained until later in the same individual. There is little doubt that the science of nutrition, by stipulating dietary standards for the more important nutrients can so improve all forms of human performance, and the length of the fully productive years, that it makes the achievement of greater objectives comparatively easy.

The information contained in this book should be of interest and value to all people who want to improve their mental and physical performance, whether at work or sport. It should be of additional interest to those responsible for the food and feeding patterns of groups of people, including students in schools and universities, young people in youth hostels and camps, members of athletic and sporting teams, participants in expeditions and patrols, members of the armed forces and workers in industry.

I

Nutrients and their Provision

To understand clearly the following chapters describing the value of various foods for human performance, it is necessary to have an elementary knowledge of the nutritive functions of the more important food components.

Food may be defined as any substance which, when consumed, nourishes the body in one or more of the following ways:

(a) furnishes the body with fuel to yield energy that appears as warmth and work;

(b) supplies the structural materials needed for the growth and upkeep of body tissues;

(c) provides substances that regulate body processes so that life proceeds normally.

Although the foods generally available for consumption vary widely, each is composed of at least one of the following components, and it is these components that give a substance its right to be designated a food.

(a) Major Food Solids
- (i) fats
- (ii) carbohydrates
- (iii) proteins

(b) Minor Constituents
- (i) mineral salts
- (ii) vitamins

(c) Water

These components may be further divided into about fifty nutrients all of which must be provided in sufficient quantity if the body is to be maintained in optimum health. Fortunately, one can acquire a sound and useful

knowledge of nutrition without studying the properties and functions of all these nutrients and a convenient starting point is a consideration of the components listed above.

MAJOR FOOD SOLIDS

There are three food components that provide the body with energy for warmth and muscular activity. They are fats, carbohydrates and proteins. This energy is measured in Calories,[1] fats providing about 255 Calories per ounce, carbohydrates and proteins about 113 Calories. Although proteins are an important source of energy, their prime purpose is for the growth and repair of tissue, a function for which they cannot be replaced by fats or carbohydrates.

Fats

Fat from any source contains more than twice the number of calories in an equal weight of carbohydrate or protein. Hence, it is man's most concentrated source of energy and, in consequence, of particular significance to those engaged in strenuous physical activity.

The physical properties of the various fats differ largely because some become liquid at lower temperatures than others. Oils are merely fats that remain liquid at ordinary atmospheric temperatures. Fats will become oils if the temperature is raised sufficiently. Some fats, such as butter fat, may be solid at winter temperatures but liquid in the summer.

Fats may be provided from animal or vegetable sources, those from the latter tending to have lower melting points than those from the former. Animal fats include the fats contained in all dairy products and various cuts of meat, whilst vegetable oils include the various oils used for

[1] The caloric content of food is always expressed in large or kilo-calories. When used to define a definite number of calories, the term is spelt with a capital C.

cooking and other culinary purposes. Mineral oils, such as liquid paraffin, and greases, such as vaseline cannot be broken down by digestion in the body and, hence, are of no value as foods. Some natural fats, as well as margarine and others that have been artificially fortified, contain certain vitamins. Because these vitamins are fat-soluble, mineral oils, as well as having no food value themselves, may reduce the food value of other fats, consumed about the same time, by dissolving from them fat-soluble vitamins which are then carried away and lost to the body.

The amount of fat that people eat is largely determined by custom but is seldom greater than that required to provide one-third the total energy content of the diet. When a man is engaged on strenuous physical work, it is a convenience, and in some circumstances a necessity, to eat considerable amounts of fat so that his food will provide sufficient energy but remain reasonably compact.[2] Even then, it is unlikely that fat would account for more than one-half the energy content of the diet.

Fat is also important because it improves the palatability of a diet and has a high satiety value, that is, it delays the passage of food through the stomach and thus gives a more prolonged feeling of satisfaction than other food components that leave the stomach more rapidly. It is for this reason that fried foods are more satisfying than boiled. Frying increases the energy and satiety values by adding cooking fats and reducing the moisture content.

Carbohydrates

Carbohydrates, which are derived almost exclusively from plant sources, may be divided into three groups – sugars, starch and various fibrous materials. The first two can be completely absorbed by the human body.

All carbohydrates absorbed by the body serve the same

[2] See M. Pyke, *Industrial Nutrition* (Macdonald and Evans, London, 1950).

purposes: they provide energy for warmth and muscular activity, or may be converted to body fat. In comparing foods with regard to the amount of carbohydrate they contain, it is usual to consider the total carbohydrate available to the body rather than the different amounts of sugar, starch and fibrous materials.

Sugars, which are the simplest members of the carbohydrate component, are all sweet in taste and soluble in water. As a readily available source of energy, they may have particular significance to those engaging in examinations of long duration, or in strenuous physical activity.[3] Glucose is the simplest of the sugars. It is available in a purified form for convenient consumption, occurs naturally in most plant and fruit juices, and can be formed in the body by the splitting of more complex sugars, such as table sugar, and by the breakdown of starch which consists of glucose units chemically combined. It is the sugar that occurs in the blood of all living animals.

By far the largest proportion of the carbohydrate in foods occurs as starch. It is in this form that plants store the major part of their food reserves. More than half the solid material in most cereal foods and potatoes is composed of starch. In the form in which it occurs in such foods, it is enclosed within granules. Starch granules cannot easily be digested and, consequently, flour, potatoes and other foods containing large amounts of starch are of little value in their raw state. When heated with water however, the starch granules swell and eventually burst, thus releasing their contents.

The stiffer structure of cereals, fruits and vegetables is due largely to the presence of various fibrous materials, such as cellulose, which can be made available to the body to a very limited extent. Consequently, they make an

[3] See 'Selected Reading', references (a) and (b). In later footnotes, items in the selected reading list will be referred to by their reference letter alone.

almost negligible contribution to the body's food requirements. They are, however, of value in giving bulk to the diet.

Proteins

Proteins, unlike fats and carbohydrates, contain nitrogen and it is by measuring the nitrogen content of a food that its crude protein content is determined.

Proteins are essential constituents of all animal and plant cells: there is no known life without them. They differ from one another because of the different kinds and different arrangements of the individual units of which they are composed. In animals, the muscle tissues consist largely of protein, which becomes available as food in the form of lean meat. In plants, the greatest amounts are to be found in seeds of which nuts, pulse and grain are particularly good sources.

Proteins are required for the growth and repair of body tissue and, for this purpose, no other nutrient can replace them. They are also used as a source of energy for warmth and muscular activity, much of the protein consumed by adults on a high protein diet being used for this purpose. Training and physical work may cause certain muscles to increase in size, strength and recuperative power,[4] but this would take place over a long period so that protein requirements would not be appreciably affected. In some situations involving a relatively long period between meals, the comparatively slow digestion and absorption of protein may be used to advantage.

The protein structure of the human body is not the same as that of plants: it is similar although not identical with that of animals. If the protein in the diet is derived from plant sources, a variety of foods must be eaten in comparatively large amounts to provide the body with all

[4] See J. H. McCurdy and L. A. Larson, *Physiology of Exercise* (Lea and Feliger, Philadelphia, 1939).

the units necessary for the construction of human protein. If the protein is derived from animal sources, less will be needed since the difference between the component units of animal and human protein is less than that between plant and human. If the protein is a mixture from animal and plant sources, the amount required may be not much greater than if it came from animal sources alone.

This is a matter of considerable importance for, in countries where meat is expensive, it means that the cost of providing protein of satisfactory quality can be reduced by including appreciable amounts of plant protein. On the other hand, in countries where meat is cheap, a purely vegetarian diet may be more expensive than a diet containing large amounts of meat. A mixed diet, containing some meat as well as peas, beans and nuts is probably the best that can be provided.

MINOR CONSTITUENTS

The minor constituents consist of mineral salts and vitamins. They are grouped together because of the small amounts in which they are required by the body.

Mineral Salts

The body's framework, or skeletal structure of bones and teeth, owes its strength and form to the mineral salts of which it is largely constituted. Much smaller amounts are present in the soft tissues and fluids of the body. Altogether the body contains nineteen major minerals and a number of others needed in much smaller amounts. All must be provided as constituents of food but only three will be discussed here.

Salts containing calcium and phosphorus are the outstanding components of bones and teeth, whilst the soft tissues of the body contain considerable amounts of phosphorus but only very small amounts of calcium. Phosphorus plays an essential part in the complex pro-

cesses by means of which the body obtains the release of energy from other nutrients. Calcium is necessary for the normal functioning of muscle and, if the level of calcium in the blood falls, muscular cramp occurs. This is not common, however, as the body has power to withdraw calcium from the bones to prevent the level in the blood from dropping.

Although most of the calcium in the body is in the form of relatively insoluble bone material, it can have a most marked effect on a person's well-being. When calcium consumption is liberal, there results a better development of the internal structure of the bones. This is most noticeable within the porous ends of the long bones where it provides an increased surface in contact with the circulating blood. This enables a more prompt and effective restoration of calcium in the blood when the concentration tends to drop following the many wastages that occur in everyday life, particularly under conditions of extra strain.

The body fluids contain about 0·9 per cent common salt and it is essential for life that this amount be accurately maintained. Salt is lost from the body in urine and, under some conditions, in sweat. The amount lost in urine is regulated by the kidneys but there is no similar means of control over that lost in sweat. If the total loss is excessive, or consumption insufficient, muscular cramps will occur. Extra salt must therefore be taken by people working in hot environments, and after strenuous physical exercise resulting in a considerable sweat loss.

The taking of additional salt has reduced muscular cramp to a minor problem in many heavy industries, and in the tropics, where it was once common. It is generally agreed that the best way in which to take salt is to add it to food as a flavour or condiment. If too much is taken, it will be harmlessly passed out in the urine, but it is essential to have adequate supplies of drinking water, otherwise mild dehydration may result. The consumption

of relatively small amounts of salt, when drinking water is restricted, can be very injurious.

Vitamins

It was largely by accident that certain nutrients came to be designated by the group name 'vitamins' for they are not a natural or closely related group. There are about 20 different vitamins, which may be conveniently divided into those that are fat-soluble and those that are water-soluble. An important fat-soluble vitamin is vitamin A and important water-soluble vitamins are those of the vitamin B group and vitamin C. Although present in foods only in very small quantities, they are all necessary for the normal functioning of the body.

When the diet is deficient in vitamin A, the body may be unfavourably affected in any one, or combination, of several ways. The first effect to be definitely recognized was a retardation of growth but the vitamin is now known to be essential at all ages. There is no evidence that vitamin A has any direct or immediate effect on muscular function, but it appears to take an essential part in the chemistry of vision. A moderate shortage is believed to cause 'night blindness'—a diminution of one's ability to see in dim light or to adapt one's vision to a change of intensity of illumination. The keenness of sight of aviators and industrial workers is reported to have been increased, and the night accidents of automobile drivers decreased, by diets of high vitamin A value.

The vitamin B group comprises a number of substances which are often, but not always, found together in the same foods. Most of them share the function in the body of forming part of the subtle machinery by means of which a steady and continuous release of energy is obtained from carbohydrate and protein. When this function is interrupted, deleterious products of incomplete combustion then circulate in the blood, and through the organs,

and could result in a failure of appetite and the onset of functional nervous disorders. A relatively mild deficiency may be responsible for ill-defined conditions resulting in apathy, mental depression and a disinclination for mental or physical work.

Vitamin C is necessary for the integrity of substances which lie between the cells of the body's various tissues keeping each cell in place and supported for the performance of its part in the functioning of the body. This involves, among other things, the prevention of blood from oozing through tissue which, during a shortage of vitamin C, may occur in almost any part of the body. It also involves the maintenance of a healthy condition of the gums and teeth, the latter becoming very susceptible to infection during a deficiency. The consumption of liberal amounts of vitamin C builds up the resistance of the body to colds, and similar diseases, and increases the ability of the body to resist the poisonous substances formed by certain species of bacteria.

WATER

Water provides no nourishment to the body but is the medium in which food is transported to the body cells, and waste products carried away from the cells. It is also the medium in which all chemical reactions in the body take place. Nearly two-thirds of the total weight of the body consists of water but the body cannot store this material. Hence it is continually balancing the amount of water consumed with that excreted.

Water requirements vary tremendously depending on the individual, environmental conditions and the physical work performed. The ideal to be aimed at is the frequent ingestion of water so that a person can keep his thirst quenched at all times. Water should never be withheld on the traditional, but false grounds, that it is injurious to men engaged on hard physical work, and that to go with-

out helps to toughen up a man. Men can withstand a lot of physical hardship but lack of water is one of the most serious of all physical handicaps. A man can never learn to get along without water, no matter how often he exposes himself to this condition. Neither can he be trained to decrease his requirement.

There is a common belief among athletes that distention of the stomach with water decreases one's capacity for strenuous exercise. Drinking large amounts of water may produce sensations of fullness, with a disinclination for physical activity, but tests have shown that performance time in swimming and track events is not adversely affected.[5] Hence, there seems to be no justification for the rigid restriction of water before an athletic event. In fact, as for other forms of hard physical work, the withholding of water may be harmful.

PROVIDING ESSENTIAL NUTRIENTS

If a person is to be fit and capable of maximum performance, the nutrients already discussed, as well as many others, must be provided in sufficient amounts according to a person's age, size and activity.

To enable this to be done in the simplest possible way, foods commonly consumed are divided into groups according to their importance as a source of certain essential nutrients. By consuming sufficient food from each group every day, there is little likelihood of the diet becoming deficient in any essential nutrient. The number of groups into which foods are divided may vary from five to eleven, the higher number being for a very explicit form of dietary planning.

Five groups into which Western-type diets can be divided will be discussed hereunder. Based on this group-

[5] See C. C. Little, H. Strayhorn and A. T. Miller, 'Effect of water ingestion on capacity for exercise', *Research Quarterly*, *20*, 398 (1949).

ing, it is essential for every person to consume each day at least two glasses of milk, fresh or reconstituted; two serves of wholemeal or enriched bread, or substitute cereals; two pieces of fruit, including an orange or tomato, and three serves of vegetables, including potatoes; one serve of meat, or as a substitute cheese; three small pieces of butter or margarine and, if possible, an egg. Such foods form the basis of an adequate diet.

Milk and Milk Substitutes

Milk is the one article of diet the sole function of which is to serve as food. It can provide significant amounts of nearly all essential nutrients, even though some would be provided in relatively low concentrations. Hence, in a well planned dietary, milk is usually included daily in relatively large amounts.

Although whole milk is a liquid, it contains an average of 13 per cent solids – an amount comparable to that in many other fresh foods. The solids of whole milk consist of fat, carbohydrate, proteins, minerals and vitamins. In condensed and powdered milks, the solids are concentrated by the evaporation of water; on reconstitution these products return to approximately their former composition. Sweetened condensed milk, which contains large quantities of added cane sugar, is an exception. For many purposes, sweetened condensed milk is too sweet to be used as a replacement for fresh milk.

Skim milk is whole milk from which most of the fat and fat-soluble vitamins have been removed. It contains about 9 per cent solids and is of particular value because of its mineral and protein content. It is the form in which milk solids are usually added to bread. When milk fat is concentrated into a fraction of the original milk, that portion is known as cream. Cream has a much higher energy value than whole milk. Cheese made from whole milk consists of the fat, most of the protein and part of the

mineral and vitamin content of milk. It is frequently regarded as a substitute for meat.

Bread and Cereal Products

Any consideration of bread immediately raises the question of the relative values of white and darker coloured breads such as brown and wholemeal. Most people prefer white bread because they like its taste and colour, and because it keeps better than darker coloured breads. Both white and darker coloured breads contain considerable amounts of carbohydrate and appreciable amounts of protein. Plain white bread contains comparatively small amounts of certain B-vitamins and minerals, and this could have an adverse effect on the health of a large majority of the people consuming it. On the other hand, most darker coloured breads contain comparatively large amounts of certain B-vitamins and minerals as well as larger amounts of fibrous materials, and an acid that renders part of its mineral content unavailable to the body.

Hence, it will be evident, that the question as to which type of bread is better, cannot be readily answered, the particular advantages and disadvantages of white and darker coloured breads being of almost equal value. A satisfactory compromise would be to use white bread made from enriched flour, that is flour containing added vitamins and minerals, or to use bread in which a small percentage of skim milk powder has been incorporated. The latter is preferred as it would also provide a small amount of milk protein.

Other cereal products of much lesser importance in a Western-type dietary include milled rice and made-up products, such as spaghetti and macaroni, as well as various breakfast foods prepared from wheat, oats, maize and rice. Rice, the most important staple of Eastern-type diets, is an outstanding food comparable in nutritive value

with wheat flour. Macaroni and spaghetti also have high food values. The most important difference between the breakfast cereals is that oaten foods provide appreciable amounts of fat and some vitamins, whereas most of the other breakfast cereals contain little fat and practically no vitamins, unless especially enriched. The latter may not, therefore, be adequate substitutes for bread.

Fresh Fruits and Vegetables

With few exceptions, the only foods of value as sources of vitamin C are fruits and vegetables, particularly the former because they are more often consumed raw. Although most fruits contain appreciable amounts of vitamin C, citrus fruits and tomatoes are particularly good sources. Most orange-coloured fruits, such as apricots and mangoes, are good sources of vitamin A. Bananas are a useful source of several vitamins but apples and pears, though popular, have comparatively low vitamin values. In cooked and canned fruits, the vitamin C content may be reduced by 50 per cent or more, so that, as a source of this vitamin, they are not as satisfactory as the fresh fruits or their juices.

During recent years, vegetables have tended to occupy a more prominent place in most Western-type dietaries. They are of particular value because of their mineral and vitamin contents: some, such as potatoes, also contain considerable amounts of carbohydrate and others, such as peas and beans, considerable amounts of protein. With few exceptions, which include sweet potatoes and sweet corn, vegetables have a comparatively low energy value. The green leafy vegetables are often grouped together because they are, in general, an excellent source of calcium and vitamin A. Carrots are also a good source of vitamin A. Broccoli and borecole, or kale, have outstanding nutritive values, but spinach is not as nutritious as is commonly supposed.

Meats and their Substitutes

Meats, including fish, poultry and game, are the most popular of the protein foods. There is little difference in the nutritive values of the proteins in red and white meats but in offal meats, such as liver, kidney and heart, the protein has associated with it greater quantities of certain minerals and vitamins. Meat consists of bundles of fibres held together by connective tissue. The size of the fibres varies considerably in different animals and from different parts of the same animal. This greatly affects the tenderness of the meat. Meat, from those parts that are exercised most frequently, has more connective tissue, and is tougher, than that from other parts. Similarly, meat from old animals contains more connective tissue and is less tender than that from young animals.

Because eggs and cheese also contain high quality animal protein, they are sometimes used as substitutes for meat. Like most meats, they contain appreciable amounts of fat but practically no carbohydrate. Common varieties of cheese contain 35-40 per cent water and are consequently very concentrated foods. Eggs have a water content of about 75 per cent. Both are important sources of some minerals and vitamins.

Butter and Table Margarine

These foods are important as concentrated sources of energy, and fair sources of the fat-soluble vitamins. The former is manufactured from cream with a high fat content, whereas the latter may be manufactured from animal fats, vegetable oils or a combination of both. Because the vitamin content of butter depends on the feed of the cow from which the butter fat originated, and the vitamin content of table margarine depends upon the level to which the product is fortified in the factory, table margarine is generally a more reliable source of vitamins

than butter. Both products contain about 16 per cent water.

Beef fat, dripping and lard are more concentrated sources of energy than either butter or table margarine, but contain no fat-soluble vitamins. Hence, in dietaries specifying butter or table margarine, beef fat, dripping or lard cannot be used as substitutes.

2

Food Utilization and Energy Requirements

Food cannot be utilized by the body until after it has been absorbed into it, that is, until after it has passed through the walls of the digestive tract. Before this can take place, solid foods have to be mechanically broken down, and relatively large organic molecules have to be chemically converted into smaller units by the process known as digestion. With the exception of water, simple sugars, inorganic salts and vitamins, nearly all common foodstuffs must undergo certain digestive changes before they can be absorbed by the body.

DIGESTION AND ABSORPTION

In the mouth, food is mechanically broken down by chewing, coarsely mixed by the action of the tongue, and moistened and lubricated by saliva, the flow of which is promoted firstly, by the anticipation of food and later, by the action of the jaws. Apart from assisting mastication and swallowing, saliva contains an enzyme or ferment that can digest starch. Hence, a small amount of starch may be broken down into sugar but no food is absorbed into the body through the lining of the inside of the mouth.

After it has been chewed and mixed with saliva, food is swallowed and passes into the stomach. There more mechanical mixing and disruption occurs and, as the food is still mixed with saliva, the breakdown of starch continues. Glands in the lining of the stomach pour out juice containing a strong acid as well as another enzyme and, together, these commence the breakdown of protein. That gastric juice is strongly acid is evident during regurgitation

when it can be sufficiently strong to burn the back of the throat. Small amounts of sugar, salts, vitamins and some water may be absorbed through the walls of the stomach into the blood stream.

Some foods remain in the stomach longer than others. This depends partly on their consistency, and partly on their composition. Foods that pass quickly through the stomach are commonly regarded as being readily digestible. However, it is not necessarily an advantage for all foods to leave the stomach rapidly because, the more quickly the stomach empties, the sooner hunger will be experienced. Foods with a high fat content possess the property of delaying the passage of food from the stomach and, for this reason, delay hunger for a comparatively long period. Hence, the stomach is capable of acting as a temporary store to the extent that it retains food until the latter has been reduced to a form suitable for transfer to the small intestine.

In the small intestine, food is further digested by bile, which enters through the bile duct, and digestive juices that contain additional enzymes. Bile does not contain an enzyme but is essential to the digestion and absorption of fats since it renders their component fatty acids more soluble. The digestive juices complete the work of converting the partly digested proteins to amino acids and the more complex sugars to glucose and other simple sugars, in which forms they are absorbed into the blood stream. The food mass is kept moving by the rhythmic muscular contractions of the walls of the intestine. Absorption occurs all along the route, and it is during its passage through the small intestine that the greatest absorption of all nutrients takes place.

It should be noted that the manner in which food is prepared affects its digestibility and hence rate of absorption. For instance, cooking causes starch granules to burst thus releasing their contents: it causes protein to coagulate

and softens any connective tissue; it breaks down the fibrous structure of such foods as fruits and vegetables. In addition, cooking performs the important secondary function of improving the flavour and attractiveness of many foods.

Finally, the food residue that has resisted digestion in the small intestine, passes into the large intestine through a valve that prevents reverse action. This residue consists of cellulose and other fibrous materials, a small proportion of which may be made available to the body by the action of bacteria. The bacteria may also synthesize certain vitamins of the vitamin B group. These substances and water are about the only materials that pass through the walls of the large intestine into the blood stream.

It has been found that exercise prolongs the digestive cycle, the delay in the emptying of the stomach being more marked when the exercise follows the meal, and it increases in proportion to the severity of the exercise. In general, the effects of exercise on the digestive cycle decreases with training. Exhaustive muscular exercise diminishes the acidity of the gastric secretions, the decrease being greatest when the exercise is accompanied by emotional excitement.[1]

There is little doubt that a person's mental condition has an enormous influence on digestive processes. This is illustrated by the manner in which worry and unresolved problems lead to nervous digestive troubles ultimately developing into organic disorders.

HUNGER CONTRACTIONS

It is now well established that sensations of hunger are accompanied by increased activity of the digestive tract, and that hunger pangs usually occur simultaneously with contractions of the stomach. Contractions reappear about

[1] See series of articles in the *American Journal of Physiology*, (1933 and 1934), by F. A. Hellebrandt *et al.* vols 105-9.

half an hour after a moderate meal has been eaten, recurring at regular intervals with periods of quiescence between. In an adult, periods of quiescence last from one to three hours, in a child they are much shorter.

At first hunger contractions are comparatively mild but gradually increase in intensity until the stomach is nearly empty by which time they are quite conspicuous. In a young child, they may cause considerable discomfort and actual pain. In an older child or adult, although not sufficient to cause pain, they may be associated with a sensation of weakness and emptiness, perhaps a slight headache and sometimes a feeling of sickness. There may also be increased excitability of the central nervous system, shown by restlessness and irritability, and a diminished ability to concentrate. In some persons, these accessory hunger phenomena appear to overshadow, if not entirely suppress, the hunger pain sensation from the stomach.

Standing or walking has no effect on hunger contractions, but running promptly inhibits them. The degree and duration of the inhibition are, on the whole, directly proportional to the speed of running. Moderate exercise, in the form of playing tennis or walking smartly for one or two hours, may result in greater hunger activity after the event with shorter periods of quiescence. This tends to make the contractions more or less continuous. Exercise taken to a point approaching exhaustion has been found to depress the hunger mechanism.[2]

Smoking, like a tightening of the belt, frequently relieves a sensation of hunger and, on occasions, there is a tendency for some people to substitute smoking for a proper meal. This is most unfortunate for there is no nourishment to be obtained from smoke. Although there is no conclusive evidence that smoking, within strict moderation, is detri-

[2] See A. J. Carlson, *The Control of Hunger in Health and Disease* (University of Chicago Press, Chicago, 1916).

mental to physical or mental performance, there is definite statistical evidence from several very reliable sources that habitual smoking may be a factor causing lung cancer.[3] The possibility of this occurring, either as a direct result of smoking or in combination with other factors, should be sufficient to condemn such an unclean habit.

Some people omit meals with the intention of giving their stomachs a rest. There is no evidence that the stomach needs long intervals between meals in order to rest, or that it ever does rest when it has such intervals. Invalids, convalescents, and patients with gastric ulcers, are fed, not at long intervals to rest their weakened or diseased stomachs, but with small amounts of food at frequent intervals. It is large meals and not frequent meals that impose a heavy burden on the stomach.

A light meal may leave the stomach in one to two hours: a heavy one may remain for three to four hours. The relatively short period during which large meals are held by the stomach has been attributed to the fact that the increased amount of food causes greater distention of the stomach which stimulates it to more effective activity.[4] There are wide variations in the times similar meals take to leave the stomachs of different individuals. In some people, they take two or three times longer than in others. Because women require less food than men, it is possible that food leaves the female stomach sooner, although the smaller size of the stomach may have an opposite effect.

ASSIMILATION OF NUTRIENTS

After food has been masticated and digested, the products of digestion pass through the intestinal wall, the fat components recombine, and all are carried by the blood stream to various parts of the body where they are utilized in various ways.

[3] E. L. Wynder, *The Biologic Effects of Tobacco* (Little, Brown & Co., Boston, 1955).

[4] See reference (c).

The tiny fat globules may be used for the production of body fat, in which case an increase in body weight eventually results, or they may be used indirectly to provide energy for warmth and muscular activity. Fat cannot be used for the production and repair of muscle tissue, a function reserved for protein alone, but it has a specific regulatory action on protein utilization as well as on one or more members of the vitamin B group.

The products of carbohydrate digestion, consisting largely of glucose, may be used to provide energy, or stored as glycogen until needed for this purpose. Glycogen, which is similar in composition to starch, can be formed from glucose in the liver and is the material in which the body's immediate energy reserves are stored, trained muscles storing more glycogen than untrained muscles.[5] If supplies of glycogen are ample, glucose may be converted to fat and laid down in the tissues.

The products of protein digestion, consisting of many kinds of amino acids, are carried to the tissues where some will be used for the growth or repair of tissue and others for the production of energy. In adults with a high protein consumption, appreciable amounts may be used for the latter purpose. In any case, since the amount and kinds of the various units of protein digestion will never exactly fit together to meet the requirements for growth and repair, there will always be some units available for the provision of energy. Under some conditions, they may be used to form body fat.

The glucose content of the blood must be maintained at a constant level if life processes are to continue normally. When large quantities of carbohydrate are consumed, the glucose content of the blood, or the blood sugar level as it is usually termed, may rise slightly but soon drops as glucose is converted to glycogen, or combusted to

[5] See J. H. McCurdy and L. A. Larson, *Physiology of Exercise* (Lea and Feliger, Philadelphia, 1939).

provide energy. Similarly, there is considerable persistence in preventing the blood sugar level from dropping appreciably, firstly by the release of glycogen and, later when the reserves of glycogen have been almost depleted and no additional food is consumed, by the use of body tissue.

Glucose is of prime importance as an immediate fuel for muscular exercise. Light exercise, and moderate exercise of short duration, does not appreciably change the blood sugar level. Long-continued moderate to strenuous exercise, however, may decrease the level, and men with the most marked signs of physical exhaustion are generally those with the lowest blood sugar levels. During endurance tests, the body's carbohydrate reserves may be practically depleted. Under both these conditions, people derive benefit from the consumption of glucose which serves as an immediate source of readily available carbohydrate.

Of all the tissues and organs in the body, the central nervous system, consisting of the brain and spinal column, is most dependent upon the constant supply of glucose by the blood. When the blood sugar level drops, those tissues and organs that have ample stores of glycogen use them to temporarily supplement the reduced supplies of glucose. Nervous tissue, however, contains little glycogen and it is doubtful whether the little it has can be mobilized for use in an emergency. Hence, when the blood sugar level falls even slightly, the brain may experience functional difficulties resulting in dullness, lassitude and premature fatigue.

Certain personality changes have also been attributed to a slightly reduced blood sugar level.[6] The perversity, impatience and ready annoyance that some people experience and manifest before breakfast are included in these changes. On the other hand, it is generally recognized that a satisfactory meal, resulting in a slight temporary in-

[6] See S. H. Bartley and E. Chute, *Fatigue and Impairment in Man* (McGraw-Hill, New York, 1947).

crease in the blood sugar level, can alter a person's mood and improve his disposition. There are, no doubt, many other factors involved.

OXYGEN FOR COMBUSTION

Human muscle can perform work by contracting. The energy required for this activity is derived from the combustion of glucose, or other material, with the release of a much greater quantity of energy as heat. The combustion of glucose and other materials for the release of energy requires the provision of a considerable quantity of oxygen and this is provided during respiration.

Respiration includes the supply of air to the lungs, the diffusion of oxygen through the lungs, the uptake of oxygen by the blood and its transport to the sites of combustion. Since the requirement for oxygen is directly related to muscular activity, and no considerable storage can occur, the provision of sufficient oxygen for physical exertion sometimes becomes crucial. When the oxygen content of the blood is lowered, two critical organs, the heart and the brain are the first to be affected. The brain has a high rate of oxygen utilization, being about 20 per cent of the total oxygen intake of the body at rest.

The human body is adapted to conditions at sea level and low altitudes. Under such conditions, insufficient oxygen is rarely a problem. As one ascends to higher altitudes, atmospheric oxygen, and hence the oxygen content of the blood, decrease. It is for this reason that mountaineering and living at high altitudes present difficulties often referred to as 'mountain sickness'. The difficulties may be first noticed at altitudes of 5,000 to 6,000 feet and become progressively greater as the altitude increases. They are accentuated by physical exertion.

The problem is of particular importance to aviators, who are provided with a supplementary source of oxygen for use when flying at altitudes of about 10,000 feet and above.

Because of the oxygen-sparing effect of carbohydrate, there is usually a preference for pre- and in-flight meals that are high in carbohydrate and low in protein. In order to maintain an adequate diet, however, sufficient protein must be consumed after the period of flying has been completed. Many aviators also avoid foods that produce bulky stools and promote gas formation, such as beans and cabbage. At high altitudes, excess gas formation can cause extreme abdominal discomfort. These precautions are not necessary for those flying pressurized aircraft.

At rest, the muscles require a minimum of oxygen, requirements becoming greater as muscle activity increases. During strenuous exercise, a trained athlete may require over ten times the minimum, and there is a corresponding strain on the respiratory and circulatory systems in providing this amount. At rest, each side of the heart delivers about one gallon of blood per minute, but during violent exercise, the amount may be increased to eight gallons. Even then, all the tissues may not be obtaining all the oxygen needed for the complete combustion of the material required for energy. This may result in the accumulation of acidic intermediates that can cause fatigue. Through training, the muscles can become accustomed to larger amounts of these intermediates with the result that fatigue from this source, as distinct from that resulting from a lowered blood sugar level, can be postponed.

It has been claimed that the suitability of a person for continued strenuous physical activity may be largely decided by determining his capacity for providing the body with oxygen as it is the process of combustion requiring oxygen that forms the basis of work output.[7]

When the tissues are not obtaining all the oxygen they need, a condition known as 'oxygen debt' may develop.

[7] See W. F. Floyd and A. T. Welford, *Fatigue* (H. K. Lewis & Co., London, 1953).

This occurs when oxygen is being used at a faster rate than it is supplied. It is usually accompanied by considerable panting until the debt is paid off. Oxygen cylinders were once a common sight at some athletic performances but are seldom seen nowadays. Complete respiratory failure is, of course, a serious emergency and, in order to maintain life, it becomes urgently necessary to apply artificial respiration, that is, an artificial means whereby air is caused to enter and leave the lungs rhythmically. In many instances, the provision of additional oxygen from cylinders is necessary.

During the combustion of fat and carbohydrate, water and carbon dioxide are formed, and during the combustion of protein, nitrogenous substances as well. The removal of this carbon dioxide is another part of the respiratory process which, in its widest sense, includes all activities concerned with the interchange of oxygen and carbon dioxide between the body and its environment. Carbon dioxide is often regarded as a waste product but this is far from the truth, a steady level of carbon dioxide in the blood being necessary for the normal functioning of the body. During muscular activity, it is the increased production of carbon dioxide that stimulates the respiratory centre thus bringing more oxygen into the lungs and blood.

It is interesting to note that, with the exception of the nitrogenous fractions of proteins, the end products of the combustion of fats, carbohydrates and proteins are the same, namely carbon dioxide and water and it is from the chain of reactions producing these substances that the energy of life is fundamentally derived.

As already indicated, special circumstances may result in only a partial breakdown of the material available for combustion, leaving behind an acid residue comprising intermediate products of incomplete combustion. Some forms of fatigue appear to be related to the presence of

these products which accumulate when they are formed faster than they can be removed. Eventually they diffuse into the circulation and reach the liver where they are converted to glycogen. At present, there is no generally acceptable chemical interpretation of the sensation of fatigue.

UTILIZATION OF ENERGY

Energy is used by the body in four ways, namely

(a) to maintain body temperature;
(b) to maintain basic processes of life;
(c) for normal everyday activities of living;
(d) for performance of occupational activities.

The amounts of energy needed by different people for each of these purposes depends largely upon the total amount of living tissue, and this has been found to be proportional to the surface area of the body. Since, in general, men have a bigger surface area than women, the total amount of energy needed by a man is greater than that needed by a woman. Age is another factor influencing energy requirements. As a person passes 25 years of age, there is a tendency to reduce physical activity and less energy is required.

Maintaining body temperature

All foods on entering the body cause a slight outburst of heat that tends to increase body temperature. For a given quantity of food, this heat is much greater for protein than for fat or carbohydrate. The effect is most pronounced at high atmospheric temperatures when large amounts of protein are consumed at a single meal. Under some conditions, a feeling of coldness may be experienced after the consumption of a heavy meal. This is not due to a decrease in the production of heat but to a withdrawal of blood from the surface of the body to cope with the increased requirements necessary to handle the food consumed.

In addition to the heat released when food enters the body, heat is being continuously released in the body by the combustion of glucose, or other materials, at a rate that is fairly constant at rest, but is greatly increased by muscular activity. To maintain normal body temperature, it is obvious that the total amount of heat produced must be equal to the amount lost to the environment. If the body produces more heat than it loses, a rise in temperature results; if it produces less, the temperature falls.

Under comfortable living conditions, the body is warmer than its surroundings and is constantly giving off heat to them. This heat is made available as a result of the tension and physical activity that is constantly taking place within the body, and in the performance of external work. There are some occasions on which the additional combustion of food is necessary to maintain the warmth of the body but, in a temperate environment, fuel combusted for this purpose would be small.

A considerable amount of heat is normally dissipated during the evaporation of water from the skin and respiratory tract. This evaporation takes place continuously and, since heat is absorbed during the process, it has a cooling effect. When heat production within the body, or the environmental temperature, rises to the point where heat lost by perspiration is insufficient or if a person becomes over-heated through wearing too many clothes, sweating may commence. The heat lost by evaporation is then greatly increased, provided the environment is dry enough for the sweat to evaporate. Sweat differs from perspiration in that it contains small amounts of common salt and other materials. The body may be prevented from becoming over-heated by reducing physical activity, keeping in the shade as much as possible, taking full advantage of any breeze and by releasing clothing at the neck, wrists, waist and ankles.

Heat may also be dissipated by radiation and conduction

in the same way that heat is lost from any warm body to its cooler surroundings. The heat lost in this way may be increased or diminished through variations in the quantity of blood flowing from deeper parts of the body to the surface, particularly the extremities. A small amount of heat is also lost in the urine and faeces.

In cold weather, if normal heat production within the body is insufficient, or protection from clothing inadequate, there may be slight pallor of the skin with capillary constriction, and body temperature may be maintained, at first by involuntary muscular tension, and later by heat produced by an increase in physical activity. This increase in activity may be involuntary and take the form of shivering or it may be voluntary and consist of stamping the feet, clapping the hands or some more positive form of work such as chopping wood. During severe muscular exertion, heat production may be increased as much as tenfold.

It is sometimes claimed that the consumption of hot food, as distinct from cold, also warms the body but the warmth provided from this source would not be very great. For instance, half a pint of hot soup would only provide about 5 Calories by virtue of its hotness. This heat would give warmth in the same way as water in a hot water bottle. It would, of course, be immediately available to the body and this could be an advantage to a cold, exhausted man. Its greatest benefit, however, would be mostly psychological. Similarly, the consumption of a cold drink may be a pleasant way of consuming extra water but it would be about as effective in reducing body temperature as a hot drink would be in increasing it.

Maintaining basic life processes

In addition to the energy required to maintain body temperature, energy is needed to maintain basic processes such as respiratory activities, the circulation of the blood

and the resting activity of the glands. The energy for both these maintenance requirements has been determined with a fair degree of accuracy by a large number of investigators.

Although the results of these investigations vary over a wide range, depending upon the subjects used and other conditions, it is generally agreed that for an average man, about 25 years of age, who is lying in bed still and warm, resting energy expenditure is just under 70 Calories per hour or 1,680 Calories per day. For a woman, about the same age, who is existing under similar conditions, energy expenditure is just under 55 Calories per hour or 1,320 Calories per day. If only eight hours are spent in bed, and the remaining sixteen hours in a more upright posture, with the subject quiescent, the above results may be increased by about 20 per cent.

More accurate results, taking into account body weight (W kilograms),[8] are given by expressions of the type $92 \times W^{0 \cdot 73}$ for men and $82 \cdot 5 \times W^{0 \cdot 73}$ for women, which can be readily evaluated by the use of logarithms.[9] These results would allow eight hours in bed and sixteen in a more upright position during which caloric requirements may be increased by as much as 30 per cent. They apply to average well nourished men and women at the age of 25 years.

The above figures are for subjects in a fasting condition. Extra energy is required during the ingestion of food, with the liberation of heat as already discussed. For an ordinary mixed diet, this extra energy has been estimated at about 10 per cent of the total energy expended. If the diet is high in protein, it may be much greater than this. Because of its greater loss of calories in the form of heat, protein may be more satisfactory than carbohydrate for a person desirous of losing weight.

Caloric requirements for basic life processes decrease as a person passes the age of about 25 years. This partly

[8] 1 kilogram = 2·2 pounds. [9] See reference (h).

results from a tendency to decrease all forms of voluntary activity. There is evidence that requirements may be reduced by as much as 3-10 per cent of the requirements at 25 years for each decade beyond the age of 25. On the other hand, the caloric requirements of adolescents between the age of 16 and 19 years are greater than those at maturity. There is evidence that requirements may be increased by as much as 13 and 4 per cent of the requirements at 25 years for males and females, respectively.[10]

Performing everyday activities

Every type of physical, and to a much smaller degree mental, activity requires the expenditure of energy in addition to that required to maintain body temperature and basic life processes. Most of these activities will involve the movement of the body or its parts and can, therefore, be related to body size.

For the normal everyday activities of living, that are common to most men and women irrespective of their occupational or sporting activities, varying numbers of calories are required. The approximate numbers of calories per hour that may be required by an average man or woman for a few of these activities are listed in Table 1.

TABLE I

Calories Required for Everyday Activities

Activity	*Man*	*Woman*
Sitting	15	12
Standing	20	15
Eating	35	27
Dressing	80	65
Moving About	125	100

Average figures for the energy expended each day on such miscellaneous personal activities might be about 350 Calories for a man and 325 Calories for a woman. They

[10] Ibid.

would almost certainly vary from day to day but, for most people, such variations would tend to follow a weekly pattern. More accurate estimates would have to take into account such factors as the amount of time spent on each activity, the speed of performance, environment temperature, body size, and age.

If the caloric requirement for personal activities is added to the requirements for maintaining basic life processes and body temperature, the total caloric requirements for an inactive type of existence are obtained. For an average man, this might be about 2,000 Calories, and for an average woman about 1,600 Calories. The number of healthy people requiring such a low number of calories would be small, and the above figures are quoted to demonstrate a further step in the build-up of the body's caloric requirements.

Performing occupational activities

In addition to the calories needed for a largely inactive type of existence, others are needed for the performance of occupational activities and recreation, the more strenuous the activity, the greater the number of calories required.

The total caloric requirement for a healthy man, 25 years of age, weighing 143 pounds and living in a temperate zone with a mean external temperature of 50°F., has been estimated at 3,200 Calories per day.[11] On each working day he would be employed for 8 hours in an occupation that is not sedentary but does not include more than occasional periods of hand physical labour. When not at work, he would be sedentary for about 4 hours daily and may walk for up to 1½ hours. He would spend about 1½ hours on active recreations and household work. For a woman, 25 years of age, weighing 121 pounds, living under the same conditions as the man, and engaged on house-

[11] See reference (h).

hold or light industrial work, requirements have been estimated at 2,300 Calories per day. Her daily activities would include walking for about 1 hour and 1 hour's active recreation, such as gardening, playing with children, or non-strenuous sport.

These estimates would vary to a small degree with climate, clothing and shelter, the effects of climate being modified considerably by the degree of protection afforded by clothing and shelter. Information on the extent to which climate affects caloric requirements is scanty but it has been suggested that, until further information becomes available, total caloric requirements for the reference man or woman, as defined earlier, be decreased or increased by 5 and 3 per cent, respectively, for every 50°F. the mean annual external temperature rises above or falls below 50°F.[12]

When calories expended in the performance of any external work, are compared with the energy value of the food consumed, also expressed in calories, the physical efficiency of the body can be calculated. The physical efficiency of the body as a performer of work is low, seldom exceeding 20 per cent. Since heat production, when the body is resting, increases after the consumption of food as a result of various digestive activities, it is apparent that energy for external work is released from ingested food less efficiently than from the body's reserves which have already been digested.

[12] Ibid.

3

Basis for Correcting Body Weight

Body weight can be used as an index of physical fitness. Best performance cannot be achieved by a person who is overweight or underweight.

The following sections are intended as a guide for persons in normal health, who desire to reach the weight at which they look, feel and perform best, and to maintain that weight for the rest of their lives. They are not intended as a guide to weight reduction by grossly obese persons, or weight increase by very thin persons. Such people should seek medical advice before embarking on any weight correcting regimen.

After a person is fully grown, and has reached his best weight, he should not gain or lose very much for the rest of his life. It was once considered inevitable and normal for people to get heavier towards middle age. It is now known that this is neither inevitable, desirable nor healthy. Because no two people are built alike, weight for height tables cannot show, with any great degree of accuracy, exactly what every person should weigh. Greater accuracy is sometimes provided by grouping people of various heights according to whether they have small, medium or large frames as in Table 2.

This table, compiled from medico-actuarial studies on hundreds of thousands of insured men and women, is given as an indication of desirable weights rather than as standards to which all healthy persons should conform. It gives weights for men and women 25 years of age and older. The weights are for people dressed in normal clothing with shoe-heels of conservative height. People vary in

TABLE 2

Desirable Weights for Men and Women aged 25 and over
(Weight, in pounds, includes normal clothing)

Height with shoes on		*Small Frame*	*Medium Frame*	*Large Frame*
Men (1 in. heels)				
ft.	*in.*			
5	2	116–125	124–133	131–142
5	3	119–128	127–136	133–144
5	4	122–132	130–140	137–149
5	5	126–136	134–144	141–153
5	6	129–139	137–147	145–157
5	7	133–143	141–151	149–162
5	8	136–147	145–156	153–166
5	9	140–151	149–160	157–170
5	10	144–155	153–164	161–175
5	11	148–159	157–168	165–180
6	0	152–164	161–173	169–185
6	1	157–169	166–178	174–190
6	2	163–175	171–184	179–196
6	3	168–180	176–189	184–202
Women (2 in. heels)				
4	11	104–111	110–118	117–127
5	0	105–113	112–120	119–129
5	1	107–115	114–122	121–131
5	2	110–118	117–125	124–135
5	3	113–121	120–128	127–138
5	4	116–125	124–132	131–142
5	5	119–128	127–135	133–145
5	6	123–132	130–140	138–150
5	7	126–136	134–144	142–154
5	8	129–139	137–147	145–158
5	9	133–143	141–151	149–162
5	10	136–147	145–155	152–166
5	11	139–150	148–158	155–169

For girls between 18 and 25 subtract 1 pound for each year under 25.

Source: Metropolitan Life Insurance Company, New York.

PLATE I. Hurdle Event requiring a Sudden Burst of Energy

Ray Weinberg, former Australian 120 yards open hurdles champion, takes the lead in an Australian Athletic Championship hurdles event. Note the complete, co-ordinated muscular effort.

PLATE 2. Lifesaving demands a Sudden but Sustained Output of Energy

Not a second is wasted as a New South Wales lifesaving squad goes into action. As the belt man prepares to dash to the rescue, the rest of the team follows with line and reel. Perfect teamwork and timing is shown by the men at the reel.

the amounts of clothing they wear, and most people tend to wear lighter clothing in warm weather than in cold. For these reasons, and others of lesser importance, it is apparent that the figures in this table cannot be very accurate. On the other hand, a table giving figures for people without clothing would be of very limited use because few people have facilities for regularly weighing in the nude. Hence, a person would have to be 10 per cent or more above his appropriate weight in the table before he could be regarded as over weight, and a person would have to be 20 per cent or more below his appropriate weight before he could be regarded as underweight.

DECREASING BODY WEIGHTS

When a person is overweight, posture is frequently poor, and bodily movements tend to be slow and awkward. This invariably leads to general inefficiency and low work production. Overweight people expend more total energy in performing work and produce more total heat in the basal state than people of normal weight.[1]

Apart from preventing an individual from achieving his best performance, excess weight can promote such ailments as backache, foot troubles and constant fatigue. For people 20 to 30 years of age, a little extra weight may do no real harm. For those 30 to 40 years of age, it is by no means good but can probably be tolerated without great inconvenience. Over 40 years of age, it can be dangerous and may lead to the development of many serious life-shortening maladies.

Overweight is due to excess body-fat. Because much of this fat surrounds vital organs, the latter tend to be weakened, and sweating may be more profuse because of the insulating effect of fat. The additional weight also places a greater load on the heart and circulatory system.

[1] L. R. Neuburgh, 'Obesity' *Archives of Internal Medicine*, *70*, 1033 (1942).

On a unit weight basis, the blood in an overweight person is less than that in a normal person. A person who should weigh 160 pounds, but actually weighs 180 pounds, is carrying with him, wherever he goes, a load of 20 pounds.

A practical test frequently employed by trainers to determine whether athletes carry excess fat, is popularly termed the 'pinch test'. It consists of pinching the skin to determine the skinfold thickness. This can be used to provide a fair indication of whether an athlete carries excess fat. There are many other practical tests. As a general rule, a man's abdominal girth should be at least two inches less than his chest girth.

Overweight invariably results when the intake of food calories is greater than the expenditure of work calories. By sufficiently reducing the intake of food calories, body-fat can be utilized to provide energy, and thus reduced. An increase in the expenditure of work calories can also reduce body-fat but is of limited value during a weight reducing programme, and will be discussed later. A reduction in caloric intake is the basis of all sound reducing programmes.

For a young person, an excess consumption of food often results from poor eating habits brought about by ignorance of food values, living or eating away from home, or insufficient will-power to choose nutritious, though possibly less attractive foods. That is, fruit instead of fancy cakes or confections. In an older person, it may mean that eating habits have not been adjusted to a decrease in activity. When eating habits form part of a pattern that has been followed for many years, persistence and determination are necessary to change them.

Heredity has often been blamed as a cause of overweight, but there is no scientific basis for such a belief. In fact, there are a number of carefully planned experiments supporting the thesis that the physical characteristics of the body are inherited but the amount of fatty tissue is

not.[2] In these experiments, identical twins were used because it is believed that such twins are identical for all body traits. If there is a difference in body-weights, environmental factors are presumably responsible.

Many athletes stop training without reducing their food intake. This can rapidly produce overweight. Exercise and food intake must be properly related to avoid overweight on one hand and physical deterioration on the other. Furthermore, the return to lower levels of activity, with an accompanying reduction in food intake, should be gradual and not abrupt. Other common reasons for overweight have their origin in the ready availability of food, the idea that plenty of food is a symbol of social standing, or the relief that food provides as an antidote to boredom.

Hence, it is important for a person who is overweight to determine the reason for his condition before attempting to correct it. Knowing the reason, and with sufficient willpower, it then becomes necessary to reduce the consumption of calories, according to a scientifically sound reducing plan, until his desirable weight is achieved. This frequently involves a large reduction in the amount of carbohydrate consumed.

Physical condition, weight to be lost and individual eating habits must be carefully considered before a safe reducing plan can be formulated. Then, determination is the most important essential. Self-denial is never very easy and the changing of long established habits makes the problem even more difficult. Furthermore, a plan should not be embarked upon with any thought of returning to former eating habits as soon as the desired reduction in weight has been achieved. To be worthwhile, a weight reduction programme must be followed by a continuous programme of weight control.

[2] See H. H. Newman, F. N. Freeman, and K. J. Holzinger, *Twins: A Study of Heredity and Environment* (University of Chicago Press, Chicago, 1937).

Foods vary in the number of calories they contain depending on their composition and, in particular, their water and fat contents. Foods with a high water content are low in calories whilst those containing appreciable amounts of fat contain most calories. Hence, when calorie intake is to be reduced, fat as well as carbohydrate, may have to be severely restricted, although not eliminated. The approximate numbers of calories contained in common portions of foods, frequently used as the basis for a low-calorie diet, are given hereunder:

Fresh fruit, 1 piece	60	Calories
Cooked cereal, 2½ ounces	53	,,
Bread, thin slice, 1 ounce	75	,,
Butter, ½ ounce	105	,,
Boiled egg	80	,,
Milk, 1 pint (21 ounces)	380	,,
Thin broth, 8 ounces	40	,,
Lean meat, 4 ounces	240	,,
Boiled potato, 3 ounces	70	,,
Other vegetables, 3½ ounces	35	,,
Wholemeal biscuit	30	,,
Water	0	,,

Fruit, canned without sugar, may be used in place of fresh fruit but at least one serve per day should consist of citrus fruit or tomatoes. One medium apple, orange or banana, three apricots, prunes or plums, or two-thirds of a cup of berry fruits are usually reckoned as one serve. An equivalent amount of fruit juice may be used in place of whole fruit. Fruit juice may also be used to sweeten the cereal, or saccharin may be added.

One slice of bread may be replaced by a medium sized potato or by half a cup of beans, peas or spaghetti. Or it may be replaced by 2½ level tablespoons of flour which, with part of the butter allowance and salt, can be used as the

basis for a sauce or gravy. Alternatively, an additional slice of bread can be substituted for a potato, which may be useful if sandwiches are to be prepared. Table margarine may be used in place of butter.

Poultry, fish or cheese may be used as a replacement for lean meat, and about $1\frac{1}{4}$ ounces of any of these foods as a replacement for one egg. Hence, if an egg is omitted, the allowance of meat, poultry, fish or cheese may be increased from 4 to $5\frac{1}{4}$ ounces. An egg may also be replaced by two level tablespoons of peanut butter.

Skim milk contains approximately 195 Calories per pint. Hence, by using one pint of skim milk instead of whole milk, the allowance of meat, poultry, fish or cheese could be increased from 4 to 7 ounces. The equivalent amount of whole or skim milk powder, or unsweetened condensed whole or skim milk, may be used in place of the fresh product, and this may be reconstituted and consumed in liquid form, or incorporated as a powder, or concentrate, in other foods.

Many other substitutions are possible and may be arranged to suit the particular likes and dislikes of the persons for whom the diet is intended. In arranging substitutions, tables of food composition will be found helpful.[3] It is important to realize, however, that only foods of similar nutritive content can be interchanged. For instance, fresh fruit, which is included largely because of its vitamin C content, could not be replaced by biscuits, which contain no vitamin C.

Some people can reduce weight without learning anything about food values. This is possible by rigidly follow-

[3] See, as appropriate: A. Osmond and W. Wilson, *Tables of Composition of Australian Foods* (Commonwealth Department of Health, Canberra, 1954), or R. A. McCance and E. M. Widdowson, *The Chemical Composition of Foods* (Her Majesty's Stationery Office, London, 1945), or B. K. Watt and L. Merrill, *Composition of Foods* (U.S. Department of Agriculture, Washington, 1950).

ing set menus and a prescribed plan. Unfortunately, such a practice prevents these people from eating many foods simply because they do not know how to substitute one food for another. They are prevented from eating away from home because the foods served may differ from those prescribed for a particular meal. Furthermore, when a desired weight has been attained, it is usually exceeded again in a very short time, because of ignorance regarding those foods that are largely responsible for providing excess weight.

Some low-calorie diets may prescribe as few as 1,000 Calories per day but such extreme diets are unnecessarily severe for the average person who needs to reduce by only a few pounds to reach his desirable weight. A diet that would provide about 1,500 Calories per day is given hereunder:

Breakfast:

Orange	1
Cooked cereal	2½ ounces
with milk	6 ounces
Boiled egg	1
Toasted bread	1 ounce
Butter	⅙ ounce
Tea or coffee	
with milk	1 ounce

Lunch:

Small tomato	1
Bread	2 ounces
Butter	⅓ ounce
Milk	6 ounces
Tea or coffee	
with milk	1 ounce

Dinner:

Thin soup	8 ounces
Lean meat	4 ounces
Boiled potato	3 ounces
Other vegetables	2-3½ ounces
Small apple	1
Tea or coffee with milk	1 ounce

Supper and Snacks:

Warm milk	6 ounces
Wholemeal biscuits	3

This diet is based on the foods listed earlier, incorporating some of the substitutions suggested. Tea or coffee can be consumed between meals as desired using, if required, portion of the milk allowed for lunch, but no sugar. Salt, saccharin, rennet tablets and flavouring extracts can be used to improve palatability and to prepare special dishes to give variety without increasing the caloric value. For instance, the egg, portion of the milk and fruit, and saccharin may be used to prepare various desserts but the total consumption of any one food should not exceed the amount listed. Part or all of the allowance of any food may be consumed between meals if preferred.

Most low-calorie diets contain considerable amounts of vegetables, fruits and sometimes raw salad ingredients. Because of the roughage contained in these foods, they could be beneficial to many people although, in the first instance, it may be desirable to introduce additional quantities slowly, so that the dietary pattern does not suddenly differ from that to which a person has been accustomed. Changing to a low-calorie diet would also alter the proportion of fat: carbohydrate : protein. There is some evidence that this may have an effect on the rapidity of weight reduction, but information on this aspect is scanty.

It would be helpful to keep a list of the foods provided each day together with the quantities actually consumed. This should involve a record of any plate waste. Such a list would serve several purposes. It could be checked against the essential nutrients to make sure there are no omissions, it could be used as a record for future reference, and it would provide convincing evidence of the calories actually ingested.

Scientific studies, on the loss in weight of persons living on low-calorie diets, have shown such losses to be directly proportional to the calorie deficit. In fact, knowing the calorie deficit the loss can be predicted with considerable accuracy. It depends on the fact that one pound of fatty tissue yields approximately 3,500 Calories. Therefore a food deficit of 3,500 Calories will lead to the utilization of one pound of fatty tissue. This is true no matter what period the calorie deficiency covers.

Frequently people go to much trouble in removing unnecessary weight and then drift back into food habits that cause it to return again. After a person reaches his desired weight, adjustment to a control diet is necessary. The change should be made gradually and carefully. At first one or two extra items should be added to the low-calorie diet, for example a light dessert or thick soup, and body weights determined regularly. If the person continues to lose weight, more substantial additions can be made, such as more meat with gravy, more milk and milk dishes and a wider range of desserts. By this means a person can eventually determine what amounts of food are necessary to maintain his desirable weight. After following a low-calorie regimen, with gradual adjustment to a control diet, appetite becomes easier to regulate and eating habits can be formed that will provide nutritious meals without excess calories.

The omission of meals, particularly breakfast, uncommon or trick diets, biscuits that swell when followed by

water, and foods in tablet or pill form, do not constitute a sound basis for permanent dietary habits and are not recommended. Only under special and unusual circumstances, and for short periods, can such expedients be of value. This does not apply to the so-called 'reducing lunch' which is a wholesome, nutritious meal with a low caloric value.

Some people have an exaggerated idea of the value of exercise in producing a calorie deficit. For the average person, a walk of one and a half miles at the rate of three miles per hour, would lead to the expenditure of an additional 100 Calories, or less than the number provided by a thin slice of bread and butter. Therefore, to lose two pounds, the average person would have to walk 15 miles per day for seven days, or play golf for 4 hours per day for the same period, without increasing his food intake. By an athlete running for one hour per day at a speed of 7 miles per hour, it could be accomplished in one week, again, if food consumption is not increased.

On the other hand, to lose two pounds whilst maintaining the same caloric expenditure, that is without additional exercise, a person would need to eat, for one week, 1,000 Calories per day less than the calories expended. This would mean a daily reduction in food consumed to the extent of about 9 ounces of sugar or 4 ounces of fat, or similar amounts of mixed foods. For many persons, this would be much easier than taking the equivalent amount of exercise. However, if planned in conjunction with a low-calorie diet, exercise can be of definite value. It should be introduced by a reorganization of daily activities so that it is taken regularly, and adapted to one's physical capacity. Strenuous exercise at irregular intervals is not advocated and may do more harm than good.

Some people may be led to believe that steam baths are short cuts to weight reduction. This is not so. The profuse sweating that a steam bath induces may cause a marked

reduction in weight due to water lost as perspiration. This water will soon be replaced by additional water consumed to quench the thirst that follows, with the result, that in a very short time, body weight has returned to its former level.

INCREASING BODY WEIGHTS

Underweight may result in poor physical capacity, premature fatigue and a lowered resistance to infection. A person 20 per cent or more below his desired weight may be regarded as underweight. In the more advanced countries, this condition is less common than overweight and may be a symptom of disease. Hence a medical practitioner should always be consulted. If no medical abnormalities can be detected, then the condition may be the result of poor eating habits, eating too little, too much activity, or not enough rest.

Many people do not eat sufficient food as a result of habit. In some families, breakfast is frequently skipped, other meals consumed at irregular intervals and many meals poorly and unattractively prepared. Eating is regarded as one of the least important of the day's activities and consequently the children in such families grow up without proper training in eating habits and with an indifferent attitude towards food.

Prolonged tension, or worry over unresolved problems, may also cause people to eat too little. This may result from financial difficulties, discontent over one's job, or strained personal relationships. In this case, it is first necessary to identify and improve the responsible emotional condition before embarking on a weight increasing programme.

With adolescents in particular, a keen desire to take part in everything, or too great an absorption in study, work or sport, and insufficient rest may result in underweight. The condition is made worse if it is accompanied by worry or

poor eating habits, which is often the position with students. In this case, a weight increasing programme must be accompanied by a reduced tempo of living and more rest.

To correct underweight, people must consume more food than their bodies utilize, so that some remains for conversion to body-fat. This can be achieved by consuming increased quantities of all the foods prescribed for a low-calorie diet, these foods being necessary for optimum health no matter what a person's weight is. In addition, large quantities of food high in fat and carbohydrate should be consumed. These include fatty meats, creamed foods, table cream, ice cream, puddings and cereals. Nourishing beverages with a high caloric value would in clude eggnog, malted milk, half milk and cream, and cocoa made from milk.

Some people, who are only a little underweight, may be able to achieve their best weights by making sure that their daily consumption of food includes all those items necessary for an adequate diet plus regular amounts of the high-calorie foods just mentioned. It is also necessary to ensure that no meals are missed. Many people as a matter of convenience, or because of expense, treat the provision of their mid-day lunch very casually. Although this meal may be the smallest of the day, it should make a definite contribution towards the day's requirements of essential nutrients.

A few people seem to have difficulty in consuming large meals, or even meals of moderate size. In this case, meals with a high caloric value but comparatively small bulk. are necessary. These may be provided by the generous use of butter or margarine, adding cream to cereals, puddings and coffee and incorporating extra quantities of fat in prepared foods. These foods should be mostly additions to what is already consumed, not substitutions.

The approximate numbers of calories contained in com-

mon portions of foods frequently incorporated in a high-calorie diet, are given hereunder. The caloric contents of other foods that should be used were listed on page 42.

Fried egg	90	Calories
Fried bacon, 1 ounce	150	"
Boiled spaghetti, 4 ounces	105	"
Meat sauce, 2 ounces	80	"
Thick soup, 8 ounces	100	"
Meat with fat, 5 ounces	720	"
Baked potato, 4 ounces	100	"
Brown gravy, 2 ounces	150	"
Ice cream, 2 ounces	110	"
Steamed fruit pudding, 6 ounces	560	"
Thick cream ($\frac{1}{2}$ pint), 10 ounces	960	"
Sugar, 1 ounce	110	"

A diet that would provide about 4,500 Calories is given hereunder. This number would be more than sufficient for nearly all women and most men, leaving some food to be laid down as body-fat. Exceptions would be men engaged on very strenuous physical work. By having larger serves and second helpings, the number of calories could be further increased to cover such exceptions. As for low-calorie diets, many substitutions and replacements can be made without appreciably altering the caloric content. In making substitutions, food composition tables will be found useful.[4]

To gain weight, the quantity of food consumed should be increased gradually, but consistently. At first this may be difficult and it may leave an uncomfortable feeling after each meal. Hence, persistence and determination are just as necessary in increasing weight as in reducing it. It will often be noticed that as nutrition improves, the appetite increases and a favourable cycle of events is instituted.

[4] See p. 43, n.

Breakfast:

Orange	1
Cooked cereal	5 ounces
with cream	4 ounces
Fried eggs	2
Fried bacon	2 ounces
Toasted bread	2 ounces
Butter	$\frac{2}{3}$ ounce
Sugar	$\frac{1}{2}$ ounce
Tea or coffee	
with cream	1 ounce

Lunch:

Boiled spaghetti	4 ounces
Meat sauce	2 ounces
Bread	2 ounces
Butter	$\frac{2}{3}$ ounce
Ice cream	2 ounces
Sugar	$\frac{1}{4}$ ounce
Tea or coffee	
with milk	1 ounce

Dinner:

Thick soup	8 ounces
Meat with fat	5 ounces
Baked potato	4 ounces
Other vegetables	2-$3\frac{1}{2}$ ounces
Brown gravy	2 ounces
Steamed fruit pudding	6 ounces
with cream	4 ounces
Fruit	1 piece
Sugar	$\frac{1}{4}$ ounce
Tea or coffee	
with cream	1 ounce

Supper and Snacks:

Warm milk	3-6 ounces
Wholemeal biscuits	

The body needs fewer calories during sleep than when awake, resting and quiescent, or when actively engaged on some physical task. Hence, additional sleep, and rest instead of physical activity, are beneficial in gaining weight. Energy expenditure can also be reduced by sitting instead of standing, walking instead of running and generally moderating the tempo of everyday living, particularly with regard to physical activity.

After a person who is fully grown has reached his best weight, he should, preferably by the use of suitable scales, endeavour to maintain this weight for the rest of his life. Many people will find it helpful to keep a record of their weights determined at regular intervals. For the best results, a person should weigh in the morning before dressing. Most bathroom scales are not sufficiently accurate to be of much value and it would be necessary to use a more elaborate type of beam scale with loose weights.

4

Physical Activity and Foods

WITH few exceptions, energy released in the body is primarily for the purpose of work, with heat as a necessary by-product. External work is the most important of those factors that raise the energy requirements above the amount needed at rest.

PHYSICAL EFFICIENCY

The efficiency of the body in performing external work is not very high. It has been found in experiments with men riding fixed bicycles that for each 100 Calories of energy consumed as food, only 10 to 25 Calories are produced as work, most of the remaining 75 to 90 Calories being dissipated as heat. The efficiency of the human body as a machine, therefore, varies from 10 to 25 per cent. In the course of ordinary industrial work, during which many external factors operate, the average efficiency may be only about 15 per cent.

Experiments have demonstrated clearly that there is little change in physical efficiency when people are placed on diets high in fat, carbohydrate or protein.[1] People have been found to be slightly more efficient on a carbohydrate diet but the increase in efficiency would not exceed 10 per cent and may be much less. On the other hand, diets containing large amounts of fat have a tendency to lower the efficiency. The reason for this is conjectural. If the amount of fat in the diet is excessive, and the body is required to convert fat to carbohydrate before it can be used to supply

[1] See C. L. Gemmill, 'The fuel for muscular exercise', *Physiological Reviews*, 22, 32 (1942).

energy to the contracting muscles, there may be a loss of energy during the conversion with the result that physical efficiency is lowered. Nevertheless, some fat is necessary to give palatability to a diet, and because of its specific regulatory effect on other nutrients including protein.

There is, however, an argument in favour of the last meal before an athletic performance of limited duration consisting largely of carbohydrate, unless the interval between the taking of food and the athletic performance is considerable, in which case appreciable amounts of fat should be included because of its high satiety value. The advantages of a carbohydrate meal would stem, not only from a possible increase in physical efficiency resulting from carbohydrate, but from the speed with which ingested carbohydrate, particularly sugar, is absorbed, and the benefits to be derived from having ample supplies of stored glycogen. Perhaps jam could be spread on bread in place of butter, and greater use made of such foods as bananas and dried fruits.

For prolonged strenuous exertion, involving the expenditure of a large number of calories, a meal containing substantial amounts of fat may be best. If the subject is trained, and his oxygen intake adequate, the utilization of this fat may result in his physical efficiency being almost as high as it would be if a meal containing large amounts of carbohydrate were used. Fatty foods that could be incorporated in the diet for the purpose include butter, cheese, peanut butter, salad dressings and various meats.

Unless the consumption of calories from fat and carbohydrate is inadequate, protein is of secondary importance as a fuel for muscular exercise. Nevertheless, its utilization for this purpose must be an efficient process since the exclusive consumption of protein does not cause a marked drop in physical efficiency during short periods of exercise.

The manner in which a person applies himself to a task may have a greater effect on physical efficiency than food.

PLATE 3. Shearing requires Sustained Effort over a Long Period

Shearing takes place all year round in Australia, but the times vary from state to state. At Young, in the central western district of N.S.W., where this photo was taken, it is done during September-October. Temperatures vary in the shearing sheds. It may be 100° in Queensland or it may be between 50° and 60° in Victoria's cooler climate. In warm weather the condition of the wool makes shearing easier, while in cooler weather the shearers are able to work harder. An average number of 110 sheep are shorn in a shearer's eight-hour day.

PLATE 4. Testing the Intensity and Duration of Energy

With a bicycle ergometer, the late Professor F. S. Cotton conducts an experiment measuring the amount of oxygen used and carbon dioxide expelled. Both endurance and short bursts can be tested on the same equipment.

For instance, it is most economical to raise a weight a certain distance when that distance is at a convenient height above the floor. As a simple example, the loading of heavy articles into a shallow open case can be performed more efficiently if the articles and case are placed on a low bench instead of the floor. The weight of the articles to be lifted, and the speed of operation, would be other factors affecting efficiency.

Physical efficiency can also be improved by training. This is due largely to the fact that training enables muscles to contain more glycogen than untrained muscles. The improvement in efficiency may occur in spite of the fact that, during intense prolonged training, diets high in fat are frequently preferred, although as already pointed out, fats tend to lower physical efficiency.

ENERGY FOR EXTERNAL WORK

Since the greater part of any physical activity, particularly in sport, involves bodily movement, it is apparent that, except in some forms of heavy work involving weight lifting, a comparatively large part of the energy expenditure ascribed to work must be charged to the cost of moving the body and its parts. This means that a major part of the work component of the total energy expenditure is directly proportional to body weight.

Investigators in many parts of the world, and under a wide variety of conditions, have made many hundreds of measurements of caloric requirements for all kinds of physical activities, both recreational and occupational. Nevertheless, there are still many activities that have not been covered whilst some of the results are at variance, and of limited value, because of the particular conditions under which they were obtained. For the comparatively simple activities, such as the common forms of human locomotion, the results are in fair agreement within a normal range of conditions.

Walking is the commonest form of locomotion and, for many people, it is the only exercise taken in an otherwise sedentary life. The energy requirements vary over a wide range depending upon a person's body weight, the way in which he walks, the speed at which he moves, and the gradient and type of surface with which he is in contact. A small person walking on the level at a speed not exceeding 2 miles per hour would require about 100 Calories per hour, whereas a large person walking at a speed exceeding 4 miles per hour would require about 360 Calories per hour. The caloric requirements for an average man walking on the level at about 3 miles per hour would be about 200 Calories per hour. If a person is walking up a slope, requirements would be increased and, if walking down, they would be decreased.

Except for athletes, running is not an important activity in the lives of most people. Calorie requirements vary over a wide range depending upon speed, gradient and surface as well as on the degree of training and physical efficiency of the runner. They could vary from about 480 Calories per hour for a person of average size running at about $4\frac{1}{4}$ miles per hour to 1140 Calories per hour for a speed of about $7\frac{1}{2}$ miles per hour.

Climbing a steep slope, or climbing stairs, involves the expenditure of a considerable amount of energy, particularly if the subject is carrying a load. Requirements for a person weighing about 130 pounds, climbing up a slope of almost 1 in 6, and carrying a load weighing about 11 pounds, would be about 580 Calories per hour. Mountaineering with a loaded haversack can, therefore, be very strenuous work.

Swimming is an unusual exercise in that it is performed in a totally different environment to other exercises. The direct contact of the body with water of a different temperature affects bodily functions much more profoundly than contact with an atmospheric environment in which

there is some protection from clothing. Caloric requirements may vary over a wide range depending upon the stroke, water temperature, and the swimmer's physical condition. For the breast stroke, at a speed of 20 yards per minute, it could be in the vicinity of 240 Calories per hour, and for the back stroke at 40 yards per minute about 600 Calories per hour.

The caloric requirements for most sporting activities vary widely not only because of the speed, body-weight, and physical condition of the participant, but also because of environmental conditions due to wind and, in the case of aquatic events, current. In canoeing, for instance, the adverse effects of wind and current could increase the energy cost as much as threefold. Few sports require a large expenditure of energy for a long continuous period, total energy expenditure for the period of the sport usually being reduced because of intermittent periods of comparatively low energy expenditure.

Domestic activities about the home are many and varied, some, such as sewing, being light and others, such as digging in the garden, being comparatively strenuous. Also, requirements for similar activities can vary from home to home depending upon a number of factors. Whether a home is on the one level or has many stairs, and whether it is equipped with considerable electrical equipment and other labour-saving devices, are some of the more important factors. The caloric requirements for a few domestic activities are included in Table 3.

The variety of tasks on which people are employed in industry is so great that is it impracticable to accurately describe or classify them. Industrialists use a variety of arbitrary gradings such as 'light', 'medium' and 'heavy' but they have no physiological basis. A female receptionist on 'light' work, who is required to operate a switchboard, type letters, and receive and introduce visitors may expend more calories in external work than a wharf labourer on

'heavy' work who is required to operate mechanical materials-handling equipment.

Furthermore, the caloric requirements for similar work in a particular trade or business varies according to the type of equipment provided and the ease with which the

TABLE 3

Calories Expended per hour during Various Activities

Canoeing, 2·5 miles per hour	120
„ 4·0 „ „ „	360
Climbing, slope 1 in 5·7, load 11 pounds	580
„ „ „ „ 22 „	640
„ „ „ „ 44 „	670
Cycling, 5·5 miles per hour	210
„ 9·4 „ „ „	360
„ 13·1 „ „ „	610
Dancing, foxtrot	250
„ waltz	280
„ rumba	360
Horse-riding, walking	120
„ „ trotting	420
„ „ galloping	540
Playing bowls	200
„ cricket, fielding	170
„ „ bowling	250
„ „ batting	300
„ golf	240
„ tennis	370
Running, 4¼ miles per hour	480
„ 7½ „ „ „	1140
„ cross country	580
Sculling, 55 yards per minute	190
„ 75 „ „ „	320
„ 105 „ „ „	610
Skiing, level, hard snow, moderate speed	590*
Swimming, breast stroke, 20 yards per minute	240
„ back stroke, 25 yards per minute	240
„ side stroke, 40 yards per minute	600

Walking, 2 miles per hour, 120 pounds body-weight	100
„ 3 „ „ „ 160 „ „	200
„ 4 „ „ „ 200 „ „	360
Work, domestic, sewing 30 stitches per minute	10*
„ „ sweeping floors	40*
„ „ washing small clothes	80*
„ „ bed-making	260*
„ „ scrubbing	360*
„ heavy, machine fitting	190
„ „ casting lead balls	230
„ „ pushing barrow holding 220 pounds	240
„ light, typing, electric, 40 words per minute	20*
„ „ „ mechanical, 40 words per minute	30*
„ „ watch repairing	40
„ medium, sheet metal	120
„ „ joinery	160
„ „ turning	160
„ very heavy, loading chemical mixer	300
„ „ hewing with a pick	420
„ „ digging trenches in clay	450

* female subjects

facilities available enable the task to be performed. For instance, less energy would be expended in operating an electric typewriter on a standard desk, than a mechanical on a high bench. Periods of very strenuous work, such as pouring metal in a foundry, are usually punctuated by frequent rest pauses. This reduces considerably the overall caloric requirement for many types of particularly strenuous work. A joiner may require only 90 Calories per hour when setting out his work but, later, when sawing hard wood, he may require 210 Calories per hour. For average conditions, requirements may be about 160 Calories per hour.

Investigations on the cost to the human body of a large number of physical activities were recently reviewed.[2] Selected results from those reviewed have been recalculated

[2] See reference (g).

to compile Table 3. The number of subjects used in obtaining some of these measurements was small, and the subjects themselves were not always typical of the people normally engaged on a particular activity. Also, many results apply to only one particular set of conditions and are of limited value. For instance, it is apparent that hewing with a pick in sandy loam requires much less energy than hewing with a pick in heavy clay and requirements could be different for all degrees of soil-compactness between these two extremes.

Hence, the results in the table cannot be regarded as more than indications of actual requirements and are subject to modification as results for larger and more appropriate groups, working or exercising under other conditions, become available. Because of these limitations, most of the results have been rounded off so that they do not convey a false air of precision and accuracy.

Using figures given on pages 33-4, and 35, and knowing the caloric requirements for a particular task, the average caloric expenditure of persons engaged in various occupations can be roughly calculated. For instance, the average expenditure of a joiner on each working day, may be as shown in Table 4:

TABLE 4

A Joiner's Average Daily Expenditure of Calories

	Calories
Basic life processes	1,680
1 hour dressing and undressing	80
1 hour eating meals	35
1 hour cycling to and from work	390
2 hours light exercise	200
4 hours listening to the radio	60
7 hours actual joinery	1,120
Total	3,565

An average figure for a typist may be as shown in Table 5:

TABLE 5

A Typist's Average Daily Expenditure of Calories

	Calories
Basic life processes	1,320
2 hours dressing and undressing	130
1 hour eating meals	27
1 hour walking to and from work	185
2 hours light domestic work	145
4 hours reading or listening to the radio	48
6 hours mechanical typing	180
Total	2,035

The totals represent the approximate numbers of calories that must be provided by food if body-weights are to remain constant and work performance continued at a normal level. The caloric expenditure of a typist is seen to be appreciably less than that of a joiner largely because the figure for basic life processes is smaller and the types of activity generally less strenuous. Caloric requirements calculated in this manner are based on a number of assumptions and estimates and, because the latter often tend to be over-generous, frequently give results that are too high. In considering large groups of people, this can provide a safety factor that will take account of individuals whose requirements are greater than average. On the other hand, for individuals whose requirements are less than average, it could lead to over-consumption.

More accurate calculations would take into account age, body-weight and atmospheric temperature. In order to determine caloric requirements with greater accuracy, for a particular set of conditions, a special investigation would be necessary. Many such investigations have been con-

ducted for operations in the armed forces. Some are reported in the review (reference (g)) to which reference has already been made. During a recent investigation of this kind, it was found that the average daily requirements of a group of 41 soldiers undergoing training in jungle warfare was 3,450 Calories, a figure considerably less than the calculated requirement.[3] Details of the investigation were as follows.

The average age was 23·4 years, height 5·8 feet and body-weight 159 pounds. The atmospheric temperature during the investigation rose from about 65°F. in the morning to 80°F. about midday and then dropped to about 70°F. in the evening. It was considered that the physical work performed by these soldiers was at least equal to that performed by the average soldier during 95 per cent of his operational life. Few men in civilian occupations would have a greater average caloric requirement; most requirements would be very much less.

For athletes and others who, in addition to their normal day's work, spend a definite period each day training or participating in some kind of sport, additional calories are needed. The results in Table 3 will enable the extra calories for this kind of activity to be estimated with a fair degree of accuracy. For instance, a person running for one hour each evening would require, during the period of this activity, about 1,000 Calories per day in addition to his normal requirement. The amounts of various foods that must be consumed to provide this number of calories can be determined from food composition tables.[4] As a check on food intake, all athletes should weigh regularly and record their weights in the form of graphs. Most of the bathroom scales available on the market, at the present time, are not sufficiently accurate to be of much value. A more elaborate, and hence more expensive, type of scales is necessary. If possible, weighings should be made

[3] See reference (i). [4] See p. 43, n.

in the morning before dressing and after emptying the bladder. Daily fluctuations of one or two pounds are not important unless they indicate a decided trend.

If too much food is being consumed, body-weight will gradually increase with the eventual development of a disinclination for physical activity. If insufficient food is being consumed, body-weight will gradually decrease, and there will generally be an involuntary decrease in physical activity affecting work output as well as the activities of everyday life. Under both these conditions, motivation can play a very important part. The enthusiasm of a young sportsman can be high enough to prevent his physical capacity from falling temporarily when food intake is insufficient, but in this case his body-weight will drop faster and evidence of emaciation appear earlier.

In considering caloric requirements over a long period, it should be remembered that the actual time a worker is engaged on the work for which his livelihood depends, is only about 20 per cent of the total number of hours in a week, that about 30 per cent of his time is spent sleeping so that about 50 per cent remains as leisure to be spent as each individual prefers. Because of this an office worker whose leisure is spent playing tennis or cutting fire-wood may actually require a greater total number of calories than a labourer whose leisure is spent listening to the radio or reading a paper. Furthermore, there is a tendency for those employed on heavy manual work to indulge in sedentary types of recreation, whereas those employed in sedentary types of occupation have a tendency to participate in physically strenuous pastimes.

FOOD FOR PHYSICAL ACTIVITY

In general, there is a dearth of information on the actual kinds of food best suited for particular forms of physical activity. A few guiding rules seem fairly well established, however.

Foods with a high sugar content are excellent sources of fuel for immediate use. Glucose tablets, in particular, can provide fuel for work with remarkable rapidity whilst cane sugar, a more complex product, is broken down into its component parts in the digestive tract so quickly that its glucose component becomes available just about as rapidly as it can be absorbed. On the other hand, the digestion of starchy foods, such as bread and potatoes, is much slower and little absorption takes place until after the food has left the stomach.

Sugars and starch cannot be properly utilized by the body unless there is available a sufficiency of certain vitamins of the vitamin B group. These are to be found in many natural foods, such as whole grain cereal products, but are completely lacking in prepared sugary foods such as glucose tablets, cane sugar and most confectionary items. Hence, although glucose and other sugary foods may be of value on special occasions in providing energy that is immediately available to the body, their utilization would depend upon the small reserves of B vitamins built up from the consumption of other foods and, consequently, they would be of little value as the main component of a regular diet.

The reason manual workers prefer large quantities of meat, and to a lesser extent cheese, may be partly because of the high percentage of fat which these foods generally contain. Pigmeats have a particularly high fat content and this could account for the popularity of ham sandwiches. Fatty foods are satisfying, not only because of their high caloric values, a matter of considerable importance to those engaged on heavy manual work, but also because of the longer time they remain in the stomach, postponing hunger pangs and thus providing a sustained feeling of satisfaction. On the other hand, if the diet contains too much fat, excessive quantities of strong organic acids may be formed as intermediate products of combustion. It

would probably be unwise to allow the amount of fat in the diet to exceed about 40 per cent; in most average diets it would be only about 30 per cent.

There is evidence that the habitual consumption of large quantities of fat, of the kind normally contained in a Western-type diet, may be a factor in the causation of coronary heart disease, which is now such an important cause of death amongst people during the working periods of their lives.[5] However, the evidence is by no means conclusive and the results of some investigations indicate that decreased physical activity, which is not necessarily unrelated to dietary fat, may be a more important factor. Other factors receiving attention include emotional stress and cigarette smoking.

It is now fairly well established that the protein requirement for an average man is slightly in excess of 2 ounces per day and for an average woman a little less than 2 ounces. Adolescents may require considerably more than these amounts. Although it is frequently claimed that high protein intakes are necessary for strenuous physical work, there is no scientific evidence to support such claims. Indeed, it would appear that increased vigour can be achieved by limiting the protein intake to about 2 ounces. When protein intake is low, it is important that the protein be of high quality, that is, from animal rather than vegetable sources. Training can cause certain muscles to increase in size and recuperative power, but this takes place very gradually and does not require sufficient protein to justify an extra allowance in the diet.

Meat, and to a lesser extent fish and cheese, are protein foods of great popularity. Cheese and many fish contain more protein than most cuts of meat, beef containing more than mutton. Because of the large amounts of water con-

[5] E. H. Hipsley, 'Some observations on the epidemiology of coronary heart disease in Australia', *Food and Nutrition Notes and Reviews, 14,* 41 (1957).

tained in these foods, it would be necessary to consume about 14 ounces of meat, 11 ounces of fish or 8 ounces of cheese to obtain 2 ounces of protein from each of these sources alone. In practice, the smaller amounts of protein contained in other foods make a considerable contribution towards daily requirements, and enable the above quantities of meat, fish and cheese to be greatly reduced.

A few years ago, it was popular for athletes to consume large quantities of meat and then engage in vigorous training to 'work it in'. This is no longer a common practice, although athletes frequently prefer foods containing a substantial amount of protein to those containing readily available carbohydrate. In some practical situations, in which there are long periods between meals, the relatively slow digestion and absorption of protein might be an advantage. Protein foods also cause smaller fluctuations in the blood sugar level and this could be a further advantage.

There is no evidence that meat is of particular nutritional significance. It often has associated with it minerals and vitamins of dietary importance, but all these can be obtained from other sources. If consumed in sufficient variety, nuts, pulse and cereal foods can provide protein of satisfactory quality, although the individual proteins in such foods are generally regarded as being of lower biological value than those in animal foods. Nevertheless, there are vegetarian races that, for many generations, have maintained themselves in excellent health, and a few prominent athletes have been vegetarians.

For athletes, a good training diet should contain adequate amounts of all essential nutrients together with sufficient calories. Essential nutrients can be provided by consuming sufficient milk and milk products, bread and wholegrain cereals, fresh fruit and vegetables, meats, including poultry and fish, and eggs. Extra calories can be provided by consuming additional quantities of such foods as butter, sardines and nuts. Sufficient fresh fruit and vegetables will

also assist in preventing constipation but they should not be consumed in excessive amounts because of their bulk. Tea and coffee should not be consumed too frequently or in large amounts.

Bulky foods should be avoided immediately before an athletic event as they are physically inconvenient, and tend to restrict breathing. In fact, experience has taught people to avoid bulky foods before most forms of physical activity and, experimentally, it has been found that physical efficiency is higher after a small meal. Sufficient calories, without excessive bulk, can usually be provided by slightly increasing the consumption of fatty foods.

Severe exercise alone appears to have little effect on the absorption of food but the strong emotions which accompany competition in all forms of sport may affect digestion and prevent high level performance. For these reasons, some athletes prefer to have no appreciable amount of food for at least 3 to 4 hours before an event. They may, however, consume small quantities of certain foods for their stimulating properties.

The long established belief that it is dangerous to swim within one or two hours after consuming a large meal is now widely disputed. There appears to be no scientific basis for such a belief but the matter needs further investigation before a definite statement can be made.

VALUE OF SPECIAL FOODS

The prescribing of supplementary amounts of certain foods to enhance physical performance, or reduce fatigue, has been practised with success in very few instances. Even then, any advantage has usually been gained by restoring and maintaining normal levels of energy supply, following long periods between meals or unusually rapid depletion, rather than by the provision of extra quantities of any nutrient.

When consumed in moderate amounts, tea and coffee

are valuable adjuvant foods. Each contains small amounts of one or more substances that can promote the increased flow of gastric juices, reduce or postpone fatigue, improve morale and generally promote a sense of well-being. In addition, any sugar, milk or cream that is added would provide additional calories as well as small quantities of some other nutrients. Both may be taken hot or cold enabling them to be consumed with almost equal popularity during winter and summer.

Apart from the calories they provide, tea and coffee are of doubtful value during training or before an athletic event. There is some evidence that they have a beneficial effect on endurance[6] but they may also cause a reduction in efficiency.[7] The methods by which tea and coffee are brewed vary greatly, and there is a corresponding variation in the stimulating properties of the resulting drinks. As usually prepared, coffee is probably more stimulating than tea.

Non-alcoholic beverages, containing materials derived from the cola nut, are increasing in popularity especially with young people. Their stimulating properties resemble those of tea or coffee, and they provide some calories because of the sugar they contain. The results of extensive studies indicate that these beverages may have a favourable effect on a person's willingness to continue hard work. Hence, like tea or coffee, they may tend to increase work output if consumed within moderation at the proper time.[8] It is unlikely that they are of particular value to athletes.

The stimulating properties of alcoholic beverages have been used since time immemorial to bolster up courage, and temporarily promote a feeling of well-being. There is no doubt that large amounts of alcohol are detrimental to muscular performance but there are differences of

[6] See reference (a).

[7] See 'Influence of coffee on efficiency', *Journal of the American Medical Association, 106*, 1136 (1936).

[8] See reference (a).

opinion regarding small amounts. The amount is difficult to define since the same quantity may be regarded as very large by a total abstainer, but small by an habitual drinker. When weak alcoholic beverages are customarily consumed in small amounts as part of a meal, no great harm may be done. Nevertheless, the consumption of alcohol by athletes and others cannot be recommended.[9]

After a sprint, a drop in blood sugar level may occur and the ingestion of glucose prior to a race is now recognized as a valuable means of delaying this drop, and postponing fatigue. The favourable effect of glucose after prolonged exhaustive work, such as a marathon race, is also well established.[10] The beneficial effects may not be due to the additional energy provided but rather to the effect of a raised blood sugar level on the central nervous system.

Glucose, a sugar with about two-thirds the sweetness of cane sugar, is available in the form of a white powder, or lightly compressed tablets which frequently have a fruity and slightly acid taste. The tablets dissolve readily in the mouth leaving a clean after-taste, and the tablets or powder may be used to prepare a refreshing drink. Glucose tablets contain about 110 Calories per ounce.

Cane sugar may be used in place of glucose and it has the advantage of being cheaper. A better substitute is fruit juice to which cane sugar has been added. This is available as a syrup that only needs the addition of water to make a palatable drink. The natural sugar contained in fruit juice may not be absorbed as rapidly as glucose but it is unlikely that this would reduce the value of the drink. The addition of cane sugar would provide a sugar that can be rapidly absorbed.

Supplementary amounts of salt may be used to advantage under certain circumstances. Most people do not require more salt than that which normally occurs in the

[9] See P. V. Karpovich, 'Ergogenic aids in work and sport', Supplement to *Research Quarterly*, *12*, 432 (1941).

[10] See reference (b).

diet. In fact, most people eat considerably more salt than they actually need. When a person engages in strenuous physical work, during which there is considerable sweating, additional amounts of salt will be lost as a component of sweat. This could rapidly deplete bodily supplies and, unless additional salt is provided, muscular cramp may result. This is frequently accompanied by tiredness, vomiting and diarrhoea.

It is inadvisable to take extra salt during periods of physical exertion but, preferably, at meal times or during rest periods, the evening being especially suitable. Hence, extra salt can best be consumed at the evening meal as a condiment. It may also be taken in the form of salt tablets or in a saline drink such as salted barley water. The latter methods have disadvantages largely because they frequently cause a feeling of sickness.

It has been pointed out that the requirements for certain vitamins of the B group may be increased many times during severe exercise, largely because of the function these vitamins share in promoting the release of energy from carbohydrate and protein – the non-fat calories. In an adequate diet, there is sufficient of the vitamin B group to affect the release of energy from all the carbohydrate and protein in the diet. However, when extra amounts of carbohydrate are repeatedly consumed, supplementary amounts of the B vitamins may be required.

Under these conditions, there could be an argument for providing a supplementary amount of B vitamins during the period that the carbohydrate content of the diet is increased. The additional vitamins could be consumed in the form of multi-vitamin tablets but it would be preferable to include in the diet small amounts of food rich in these vitamins, such as edible yeasts or vegetable extracts. The whole subject raises the interesting problem of whether the amount of strenuous exercise that can be performed is limited when the intake of vitamins from the B group is

insufficient. As far as the author is aware, the matter has not been satisfactorily investigated.

There is some evidence that a high intake of vitamin C minimizes muscle soreness in athletes engaged in unusually strenuous muscular activities.[11] It also appears to reduce foot troubles, such as swellings and pains, in soldiers marching under adverse conditions. The high intake of vitamin C should be commenced some days, or perhaps weeks, before the strenuous exercise is commenced, and continued during the period of the exercise. For most people, sufficient vitamin C would be provided by the addition to a normal diet of two or three average-sized oranges, lemons or tomatoes, or their juices, per day.

With these possible exceptions, there is no scientific evidence that the consumption of vitamins in excess of the amounts needed for a normal adequate diet is in any way beneficial during physical performance.[12] In fact, care should be taken not to consume vitamins in excessive amounts (for instance, by supplementing an adequate diet with vitamin tablets) as this would not only be of no value but, with some vitamins, could be harmful because of their toxicity in large amounts.

From time to time claims have been made that various other substances, such as phosphates, gelatine and soyabean concentrates will assist in improving performance.[13] None of these claims has been substantiated. Provided an adequate diet is consumed there is, in general, no way of improving physical performance by means of food. The individual undergoing strenuous physical training, like the

[11] See W. M. Staton, 'The influence of ascorbic acid in minimizing post-exercise muscle soreness in young men', *Research Quarterly*, 23, 356 (1952).

[12] See 'Vitamin supplements and performance capacity', *Nutrition Reviews*, *8*, 312 (1950) and 'Vitamin supplementation and physical performance', *Nutrition Reviews, 13*, 102 (1955).

[13] See reference (a), and W. M. Staton, 'The influence of soya lecithin on muscle strength', *Research Quarterly*, 22, 201 (1951).

individual engaged in heavy manual work, will have a greatly increased need for calories but, as long as these are provided in a way in which they are readily available to the body, no marked changes in the dietary are necessary or advisable.

On the other hand, poor eating habits and the consumption of large quantities of food at one meal can be a definite handicap. Skipping meals, especially breakfast, and over-eating at a subsequent meal, particularly lunch, will result in detrimental effects that can be reflected in poor performance with a decreased work output and reduced mental acuity.

FATIGUE AND STALENESS

Although fatigue is an experience with which all people are familiar, it is most difficult to define. It is generally associated with a feeling of tiredness and a reduction in work output as a result of work.

At the present time there is no generally accepted chemical interpretation of the sensation of fatigue. Nevertheless, insufficiency of oxygen is likely to be accepted as one of its possible causes. This lack of oxygen may be responsible for the accumulation, within the body, of organic acids that cause fatigue, or for the impairment of some continuous bodily function. There is some evidence that both conditions may be involved.[14]

When fatigue results from an accumulation in the body of products that could not be eliminated as rapidly as they were formed, the obvious remedy is rest, to prevent further accumulation. This would also enable the body to dispose of products already accumulated. During training, the muscles learn to tolerate these products to a greater extent, and so fatigue may be postponed. It cannot, however, be postponed indefinitely and places a ceiling on human work capacity.

[14] See S. H. Bartly and E. Chute, *Fatigue and Impairment in Man* (McGraw-Hill, New York, 1947).

It has been suggested[15] that in order to prevent fatigue, gross energy expenditure should not exceed an average figure of about 300 Calories per hour for a normal working day. Beyond this, the accumulation of products in the body would be sufficient to cause fatigue. Hence, if occupational work covers eight hours per day, the gross energy expenditure during this period would be 2,400 Calories. Substituting this figure for the figure for 7 hours' joinery and 4 hour's listening to the radio on page 60, and taking two-thirds of the figure for basic life processes, the total result would become 4,270 Calories. It has been suggested that a figure of this order represents the upper limit of energy expenditure that can be regularly maintained by the average worker employed in heavy industry. It is equivalent to a daily walk of about 25 miles.

Food intakes greater than 4,270 Calories have been recorded but generally by special groups, engaged on particularly strenuous work, whose members have physiques far above normal. Other workers, required to work in awkward or unusual positions, may suffer from fatigue in certain limbs or parts of the body and, because of this, could have a much lower limit of energy expenditure.

A valuable means of postponing or easing the form of fatigue associated with a lowered blood sugar level is the consumption of glucose, or some other sugar, before or after the event.[16] When a sudden burst of energy is required, for instance during a sprint, sugar may be taken just before the event. When there is a continuous heavy expenditure of energy over a long period, for instance during an endurance test, sugar may be taken immediately after or during the event.

When work or exercise is continued for many days or weeks without sufficient rest, and sometimes nourishment, there may develop a state of chronic fatigue and loss of weight, which is frequently referred to as staleness. It has

[15] See reference (g). [16] See reference (b).

been observed among industrial workers, soldiers and athletes. During athletic training, a further contributing factor may result from dietary restrictions and self-denials that are too rigid.[17] An analysis of the situation usually reveals that there is also an intense emotional factor involved, and that it is anxiety more than overwork or dietary restriction that has been chiefly responsible for the condition.

The treatment seems fairly general. Persons suffering from staleness should continue their participation in exercise but the intensity should be reduced, their diet should be checked to make sure it is providing sufficient of the essential nutrients, and periods of rest should probably be increased. Considerable encouragement and assistance may be needed to regain self-confidence.

A factor that may sometimes contribute towards poor performance by workers remaining for long periods in one position, is the undue transfusion of blood from the limbs and trunk to the head, thus impairing the efficiency of body processes dependent upon normal circulation. The consumption of food together with associated physical movements will induce the blood to return to normal circulation with a tendency to concentrate in the lower part of the trunk where it is needed to assist with digestion and to carry away the products absorbed from the intestinal tract.

[17] See 'Nutrition of athletes', *Nutrition Reviews*, 7, 315 (1949).

5

Mental Activity and Concentration

Energy supplied to the body in the form of food can be expressed quantitatively in terms of heat units or calories. Resultant physical work can be expressed in the same units, so that it is possible to compare the amounts of energy required for the performance of various kinds of physical work, and to calculate the physical efficiency of the body in performing this work. Mental work, which is less tangible, cannot be expressed in the same units and, to date, it has not been possible to determine the energy required for various kinds of mental work, nor to calculate mental efficiencies in the same way as physical efficiencies.

During intense mental concentration, there would be greater activity within the brain tissue and a slight increase in both oxygen consumption and heat production, requiring increased muscular activity from the heart and lungs. The energy required for such activities would be small and for voluntary mental concentration, would probably be less than 5 per cent more than that required for a simple state of attention.[1] That is, considerably less than 1 Calorie per hour which, in comparison with total bodily requirements, is practically insignificant.

On the other hand, it has been demonstrated that thinking may be associated with unconscious movements of the lips and tongue, or mental images recorded in terms of muscular tensions, and the energy required for such activities may be large in comparison with that required

[1] See F. G. Benedict and C. G. Benedict, *Mental Effort in Relation to Gaseous Exchange, Heart Rate, and the Mechanics of Respiration* (Carnegie Institute of Washington, Publication 446, 1933).

for thinking alone.[2] Many kinds of mental work have, as their complements, a necessary and definite amount of physical activity. A simple arithmetic calculation may involve mental work only, but a more difficult calculation, that has to be worked out on paper, involves physical work as well. Learning a poem aloud involves physical work in speaking, as well as mental work in learning.

When used in relation to mental work, the word 'efficiency' is a loose term covering the speed or accuracy with which a mental exercise is performed in comparison with a previous or subsequent performance. Even this comparison is not easy to make, for almost all mental exercises are subject to improvement with practice, and often a very marked improvement may be noted from one repetition of the exercise to another. Two important factors that affect mental efficiencies in opposite directions are lassitude, resulting in a disinclination for mental activity, and concentration involving the ability to shut out distractions.

Unlike physical work, mental activity is not only of no value to a person following a weight reducing programme, but it may lead to an increase in body-weight. The calories expended during mental work are practically insignificant and the performance of such work unnecessarily, may prevent a person from engaging in physical activity during which many calories may be expended.

DAILY WORK OUTPUT

Figure 1 is a typical daily production curve for a routine industrial operation in which the human element plays a prominent part. It is a composite curve in which various tendencies occurring in the curves for specific operations are cancelled out. It was prepared to show the difference in working rates after the consumption of large and small midday meals. The data from which the curve was drawn

[2] See W. A. Shaw, 'The relation of muscular action potentials to imaginal weight lifting', *Archives of Psychology*, No. 247 (1940).

were such that a quantitative comparison could not be made.[3]

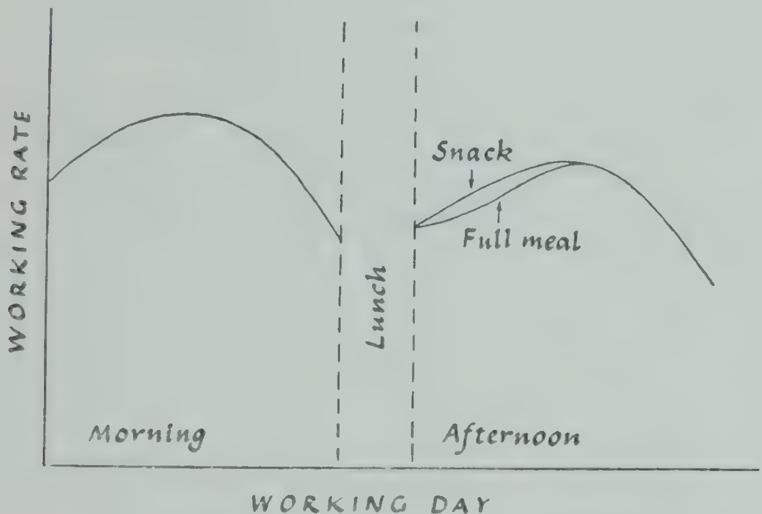

FIG. 1. Typical Daily Production Curve

Most production curves show a marked increase in production rate during the early hours of the morning and afternoon, and a decrease during the late hours. This decrease does not necessarily reflect a lessened capacity for work but could be the result of a disinclination to work to capacity. The general pattern appears most clearly for the heavier types of physical work but also exists for many types of sedentary work. The prime cause of these variations is still obscure, although the increases have been loosely attributed to 'warming-up' effects and the decreases to fatigue or reduced motivation.

In the case of physical work, there is an apparent need for warming-up but, in the case of mental work, it is doubtful if such a process ever occurs, particularly during the afternoon work period. It is generally recognized by many students and office workers that, if free from inter-

[3] See reference (c).

ruptions, their best work can be performed during the first part of the morning work period. After lunch, output generally commences at a low level increasing gradually until it reaches its maximum about the middle of the afternoon, and then begins to decline. If a large midday meal has been consumed, there is a definite flattening of the production curve immediately after the return to work.

The consumption of a large meal, such as the main meal normally consumed by a person on a regimen of three meals a day, is generally followed by drowsiness, lack of co-ordination and disinclination for mental or physical activity.[4] The majority of people who work in offices or are engaged on other types of mental work are thoroughly familiar with the feeling and the lowered work output that results. It is because of this feeling that many business executives will not eat a large midday meal unless they are in a position to have an extended lunch recess.

Several theories have been advanced to account for this condition. One explanation is that there is a temporary 'brain anaemia'. Digestion requires a full supply of blood to the stomach and this necessarily creates a relative deficiency in other parts of the body, including the brain. Here, the blood supply may be sufficiently poor to have an adverse effect on mental performance, the condition lasting until the greater part of the meal has been digested. This places limitations on the value of a large meal consumed at any time during the working day. On the other hand, a light meal consisting of a serve of sandwiches with tea or coffee may leave the distribution of blood relatively unaltered, allowing the supply to the brain to remain almost normal.

Eating large meals is not the only activity during which the distribution of blood within the body is slightly altered. Quite often, in emotional reactions, one can observe

[4] See reference (e).

changes in the distribution of blood to the head. Extreme changes include blushing for shame, when the blood supply is increased, and the pallor of fear, when it is reduced. Physical exercise diverts the flow of blood to the muscles, and it is not only undesirable but may sometimes be dangerous to exercise too soon after a large meal.

The production curve given earlier represents average working rates for large numbers of people, the working rates for individuals varying widely as a result of many personal factors, some inherited. Most working rates, however, follow the same general trend. It has been claimed that the general decrease in working rate during the late hours of the morning and afternoon, particularly for sedentary workers, may be partly the result of a nervous condition that occurs when the last meal has practically disappeared from the stomach and hunger contractions have become pronounced.[5] The condition comprises general irritability and restlessness making continuous concentration on everyday matters increasingly difficult. It is a condition that also characterizes the fatigue state although not always associated with it.

Concentration consists of the ability to shut out all distractions and focus the mind on one particular subject. There are two types of concentration – involuntary and voluntary.[6] The former is spontaneous and the latter guided and controlled by will-power. Involuntary concentration is aroused without any effort generally as a result of the stimulation of one of the instinctive tendencies. Voluntary concentration requires the effort of thinking according to a plan and this is the type that can be influenced by food, being reduced after a large meal and during long periods between meals.

In addition to the onset of hunger contractions, and

[5] See reference (f).

[6] See S. F. Woolley, *The Power of Concentration* (Pitman, London, 1948).

their effect on concentration, a reduction in the blood sugar level, resulting in a feeling of fatigue, could be another factor accentuating the difficulty some people experience in concentrating during the late hours of the morning and afternoon. If motivation is sufficiently great, the ability to concentrate will not be diminished, but in most routine activities, unlike tests or examinations, people tend to work as they feel rather than under the stimulus of constant motivation.

There is definite evidence that the mid-morning and mid-afternoon consumption of small amounts of solid food may increase ability to concentrate from the time the food is consumed until the next meal is taken and, for those at work, an increase in production rate will almost certainly result.[7] If the food is accompanied by tea, or coffee, the latter could also serve as a stimulant to sedentary workers. Each contains small amounts of one or two substances which, in addition to their stimulating properties, can improve morale and generally promote a feeling of well-being. They may also assist in postponing a feeling of fatigue.

There is evidence that mental concentration, as distinct from physical practice, is important in achieving certain simple skills such as throwing basket balls, shooting darts or tossing rings. Improvement has been found to result when periods of mental concentration, during which the skill being facilitated is mentally pictured, replace periods of physical practice.[8] Difficulty has been experienced in concentrating for periods longer than about 5 minutes. It seems reasonable to assume that these periods of concentration would be most effective if undertaken when the adverse effects of an empty stomach, or over-eating, are absent.

[7] See reference (f).

[8] See W. E. Twining, 'Mental practice and physical practice in learning a motor skill', *Research Quarterly*, 20 432 (1949).

STUDY AND EXAMINATIONS

During recent years spectacular claims have been made that intellectual performance and capacity for study can be improved by the consumption of special meals, or particular dietary components. None of these claims has been subsequently confirmed for normal people living on an adequate diet. Several, however, deserve brief mention.

Claims have been made that certain vitamins of the vitamin B group can improve mental performance, particularly learning capacity.[9] Because these vitamins enter into the processes by means of which a steady and continuous release of energy is obtained from carbohydrate and protein, and because a mild deficiency can result in subjective symptoms such as headache, irritability, nervousness and poor concentration, there seems little doubt that a deficiency can adversely affect mental performance. However, the experiments used to support claims, that the provision of excessive amounts of B vitamins can improve mental performance, do not bear critical examination, and there is no scientific evidence that the mental performance of people on adequate diets is improved by the ingestion of an extra allowance of B vitamins. On the other hand, an over-dose of any vitamin is not only of no value but may even be harmful.

One of the amino acids, glutamic, has received much attention as a possible brain food although the results of several well-controlled tests have been predominantly negative.[10] The reasoning that led to this work was largely as follows. The brain contains appreciable amounts of the acid, hence it is believed to be necessary for brain activity and it was also believed, by some people, that the more that is provided, the better the brain will function. The

[9] See reference (b), and 'Thiamine supplementation and learning capacity', *Nutrition Reviews, 7,* 220 (1949).

[10] See 'Glutamic acid and mental functions', *Nutrition Reviews,* 9, 113 (1951), and 'Effect of glutamic acid on intelligence', *Nutrition Reviews, 11,* 201 (1953).

fact that most dietaries contain more than sufficient and that, in any case, the acid can be synthesized within the body, appears to have been overlooked.

The suggestion that, because of its phosphorus content, fish may be a food of particular value to the student is also without scientific justification. In fact, there are no nutrients or foods that are known to improve any aspect of mental performance unless by remedying a dietary deficiency. In an adequate diet there are no deficiencies. The belief that hunger sharpens the wits also has no scientific basis. Motivation can sometimes postpone the distracting effects of hunger, but not indefinitely, nor as a matter of routine. An adequate diet, and a regular feeding pattern without over-consumption at any meal, provide the best conditions for study.

It is possible that many students obtain lower marks at examinations because they do not give sufficient attention to the consumption of food before the event. A written examination may not require the expenditure of much energy, but it requires a high degree of concentration and mental alertness. Most hungry individuals find it difficult to concentrate under the stress of an examination and, in general, an overfed person cannot remain alert for long periods. This means that students should never skip a meal before an examination, nor consume a very heavy meal.

A light breakfast or lunch with only a moderate amount of liquid should not cause physical discomfort, but be an advantage to most examinees. The meal should consist of foods that are liked, be consumed slowly in a happy frame of mind and, if possible, with pleasant companions. Tea, or coffee, may be included if one is accustomed to drinking it. Otherwise it should be left alone, because just before an examination is not the time to experiment with unaccustomed foods. For examinations of long duration, it may be found beneficial to take a glucose tablet or piece of

barley sugar 2 or 3 hours after the last food was consumed.

Visual work is so closely allied to mental work, particularly the work of a student, that it seems more appropriate to mention it here than in the discussion on physical activity. The muscular effort required for visual work, and consequently the energy expenditure, is extremely small. Nevertheless, visual fatigue is one of the commonest forms of fatigue and, for many people, it places a ceiling on their level of mental activity.

The best type of meal for those engaged on strenuous visual work has been the subject of limited investigation and, to date, the results have not provided information of great practical value. There is some evidence[11] that a carbohydrate meal may not be the most suitable to precede strenuous visual work, and that a meal with a high fat content may be more suitable. However, the information is too scanty to be of general application and there seems to be little justification for any change from a normal mixed meal that forms part of an adequate diet.

FATIGUE AND BOREDOM

Fatigue and boredom are important factors contributing towards low levels of mental performance.[12]

It is difficult to distinguish between physical and mental fatigue. A familiar difference is to be found in their emotional reactions: in most cases of physical fatigue there are positive feelings of tiredness, soreness, etc., but the effects of mental fatigue are experienced through a negative or indirect feeling of lassitude and disinclination for work. Mental fatigue could be no more than an experience resulting from an over-activity of brain tissue. In this case, any basic difference between physical and mental

[11] See E. Simonson, J. Brozek and A. Keys, 'Effect of meals on visual performance and fatigue', *Journal of Applied Physiology*, *1*, 270 (1948).

[12] See S. Wyatt and J. N. Langdon, *Fatigue and Boredom in Repetitive Work* (Her Majesty's Stationery Office, London, 1952).

fatigue may be largely one of degree. For instance, as a result of strenuous exercise, there may be aches and pains in various muscles. On the other hand, as a result of concentrated thinking, the small muscles of the face may become tired and uncomfortable.

Mental fatigue appears to be associated with a low blood sugar level, and it may be for this reason that students, who miss meals in order to study or attend lectures, claim benefit from the consumption of small amounts of sugar. A nutritious snack would, if available, be very much better. Additional oxygen also appears to be beneficial and it has been found that people, engaged on intellectual tasks indoors, think better after a short walk in the open air which, apart from providing more oxygen, also serves as a circulatory stimuli. Stuffy internal accommodation with insufficient oxygen, promotes drowsiness and a reduced inclination for mental work.

It is well known that, in many industries, the accident rate tends to increase towards the end of a work period.[13] This increase has been partly attributed to mental fatigue although other factors, such as diminished concentration, could be also involved. When men and women are working under similar conditions, there is evidence that accidents are more numerous with women than men. Definite breaks, during which a small amount of food is consumed, provide an economic means of combating the factors causing mental fatigue after long periods of work in a sedentary position.

In schools, play periods and a nutritious snack are also important, although lack of attention generally occurs before children can experience a marked degree of fatigue.

Food has no direct effect on boredom but, indirectly, meal habits are important in several ways. Boredom is a personal experience that cannot be directly observed or

[13] See *Australian Industry and the Rest Pause* (New Century Press, Sydney, 1939).

measured. It is partly dependent on personal characteristics and tendencies, and partly on the type and conditions of work or other occupation.

Under social conditions, boredom can develop through lack of interest arising from the dullness or tedious iteration of a speaker or performance. In industry, it is common with people engaged on repetitive work. For such people, it has been found to be most marked around the middle of the work period and is associated with increasing restlessness, a lower and more variable rate of work and an apparent awareness of the slow passing of time. People become bored when there is nothing to distract their attention from the monotonous conditions of their occupation. On the other hand, if capacity for mental detachment is slight, so that work or social occupation is the focus of attention, boredom is less likely to arise.

It has been observed that boredom is particularly noticeable in industrial operatives engaged on semi-automatic processes requiring sufficient attention to prevent mind wandering but not sufficient for complete mental absorption.[14] Furthermore, it is most noticeable in the more intelligent types of workers who could be better employed in occupations making greater use of their abilities. Steady persistence is necessary for monotonous repetitive work, and this is less likely to be found in individuals who are intelligent, expressive and easily distracted. Nevertheless with increased mechanization of industry, the general intelligence level of workers engaged on semi-automatic processes is likely to increase, with boredom becoming a greater problem.

An effective antidote to boredom in the more intelligent worker is the ability to think of things apart from one's occupation. Thus a worker on repetitive work is less likely to be bored when his mind is full of the thought of the

[14] See H. M. Vernon, *The Health and Efficiency of Munition Workers* (Oxford University Press, 1940).

midday meal he is soon to enjoy. Morning and afternoon tea breaks change the outlook of workers by providing intermediate objectives as well as shortening the duration of work periods. Morning tea breaks are also important because many workers have little or no food before leaving for work and, unless there is a tea break, may have to wait five or six hours for the first substantial meal of the day. Under such conditions, these workers may be distracted by hunger and a longing for food, and time would appear to pass even more slowly.

By reducing fatigue and boredom, with their resultant carelessness and reduced motivation, there would be a decrease in proneness to accidents, most of which are due to the human element, and a general increase in productivity to the extent that this is dependent on human effort. Many other factors are, of course, involved but it can be no mere coincidence that morning and afternoon tea breaks are followed by a marked improvement in performance and a falling off in those unsafe acts of carelessness which are due to fatigue and boredom.

6

Desirable Feeding Pattern

UNTIL recent years it was customary for many people to have only three meals a day, and there were some people who actively discouraged the consumption of food between these three meals. The custom of having only three meals a day probably developed as a matter of convenience and not because it enabled a person to utilize his abilities to the best advantage.

During the last few years it has become common practice, particularly in schools and to some extent in industry, to have morning and afternoon snacks, and the popularity of light suppers appears to be increasing. The desirability of having these meals is no longer in doubt, but more attention could be paid to the types of food consumed for morning and afternoon snacks, and to the amount of food consumed at each of the remaining meals.

Because morning and afternoon snacks, and suppers, are generally regarded as providing extra food, there is a natural tendency to reduce their size. Restrictions are unnecessary, however, if the food consumed at the main meals is adjusted so that there is no appreciable increase in the total amount of food consumed. Snacks and to some extent suppers could then take a definite place in the daily dietary and could be chosen so as to make a specific contribution towards daily requirements, with regard to both calories and nutrients.

When the number of meals is increased, smaller quantities of food are required at each meal. Within practical limits, the frequent ingestion of small quantities of food is very desirable and is an established practice in the feeding of infants, and adults suffering from certain digestive

diseases. Such a regimen imposes a different set of conditions on bodily functions. The range of variations in some functions such as body temperature, is modified, and a more even work output can be maintained throughout the working day.

Although the consumption of extra food, by a well nourished person, cannot produce a significant improvement in mental or physical performance, food consumption after a fast of several hours, or after strenuous physical exercise, may assist in relieving fatigue, and improve one's ability to work by returning the body to its former well-nourished condition. The improvement following breakfast is largely due to the arrest of a gradual depletion, and to the rapid replenishment, of immediate bodily reserves.

BREAKFAST

Breakfast is the most important meal of the day and should never be omitted.

At breakfast, it is usually 10 or 12 hours since food was last consumed. As a result, the body's immediate energy reserves are considerably reduced and additional supplies of fuel are of value in maintaining normal work performance and preventing the development of premature fatigue. There will be no food left in the stomach to prevent the onset of hunger contractions and, for most people, there will exist an uncomfortable feeling of emptiness. The body will be in need of water to replace that lost as insensible perspiration and in the urine.

The lowering of immediate energy reserves, together with a reduced circulation of the blood, frequently results in a form of physical and mental sluggishness which may disappear to some extent as the body engages in greater physical activity. Under such conditions, a person's general efficiency and capacity for physical work is low, and he will remain in this condition until a satisfactory meal has been consumed.

Breakfast is one of the quickest and easiest meals to prepare, yet it is the meal most often neglected, even at the risk of impairing health. One reason commonly advanced by women for the omission or skimping of breakfast is the desire to reduce body-weight. During weight reduction, nothing can be gained by omitting breakfast and spreading the day's intake of calories over the remaining meals. It is far better to spread the day's intake over all meals including breakfast.

Many scientific studies have shown that people who eat an adequate breakfast are more efficient than those who do not, and that factory workers who skip breakfast are more prone to accidents than those who report for work well nourished. Many people have developed the habit of having only tea and a small amount of toast for breakfast. Tea, or coffee, may serve as a temporary stimulant but the basic requirement at this meal is for calories.

Breakfast should supply about one-fourth of the day's caloric requirements, together with a fair share of the day's essential nutrients. Calories greatly in excess of this amount should not be consumed if planned mental or physical activity is to follow within the next hour or so. The types of food consumed are not of great importance for it has been found that a person's work capacity is approximately the same whether his breakfast comprises cereal foods, including large quantities of starch, or foods of animal origin, containing appreciable amounts of protein.[1]

Most breakfasts can be planned around the provision of fresh fruit or fruit juice, whole grain cereal foods, butter or table margarine, adequate amounts of milk and, if possible, an egg. For those requiring a more substantial breakfast, the amounts of bread and butter and number

[1] See series of articles in *Journal of the American Dietetic Association*, vols. 26 and 27 (1950 and 1951), by W. W. Tuttle *et al.*

of eggs may be increased and, if desired, a breakfast meat added.

Typical menus for breakfasts that would provide approximately 800 Calories are given hereunder:

(a)	Fresh fruit	1 piece
	Cooked cereal	5 ounces
	with milk	6 ounces
	Toasted bread	2 ounces
	Fried egg	1
	Fried bacon	1 ounce
	Butter	$\frac{1}{3}$ ounce
	Sugar	$\frac{1}{2}$ ounce
	Tea or coffee	
	with milk	1 ounce
(b)	Stewed prunes	$\frac{1}{2}$ cup
	Shredded wheat	1 ounce
	with milk	6 ounces
	Toasted bread	3 ounces
	Butter	$\frac{1}{2}$ ounce
	Sugar	$\frac{1}{4}$ ounce
	Tea or coffee	
	with milk	1 ounce

LIGHT REFRESHMENTS

Rest pauses during the morning and afternoon have long been recognized as beneficial because they eliminate or reduce fatigue and boredom, and improve one's ability to concentrate. Few people can work uninterruptedly for 4 or 5 hours without the need for food and a rest. In industry, it is far better to have an organized rest pause of about 10 minutes' duration, with light refreshments served under hygienic conditions, than a rest pause of indefinite duration, enforced through necessity, during which food and drink are surreptitiously consumed.

Employers were at first disinclined to introduce rest pauses because they meant a loss of working time and

this, it was believed, would result in a decrease in work output. However, investigations conducted in a number of industries showed that, in the large majority of cases, the introduction of rest pauses led to a greater work output despite the working time lost. In some instances, the rest pauses were abused, but it is a responsibility of management to prevent this from happening.

Organized rest pauses are almost invariably accompanied by the provision of refreshments. This is especially desirable in factories and offices employing large numbers of young girls many of whom rush to work without adequate breakfasts. In general, their work performance commences at a low level continually decreasing until food is consumed. However, the prime purpose of rest pauses is to make a high level of performance easier, not to make it possible. Where they are fulfilling the second purpose, they are not being used to the best advantage.

The food consumed during mid-morning and mid-afternoon should, on each occasion, provide up to one-eighth of the day's caloric requirements and have a definite nutritional value. It should consist of such foods as sandwiches and rolls with substantial fillings, rather than sugary sweets and fancy cakes. Older people with poor teeth may have to be especially catered for by providing nutritious foods without crisp or tough crusts, otherwise they will tend to choose sweet, fancy cakes of low nutritional value.

Solid foods suitable for consumption during mid-morning and mid-afternoon rest pauses are listed hereunder. Their caloric values increase progressively from about 90 to 300 Calories. The list is not complete but indicative of the kinds of food that should be provided. Tea, coffee, soup or milk would be suitable beverages.

Because facilities are not generally available for cleaning the teeth after consuming light refreshments during the morning or afternoon, sweet sticky foods that remain about the teeth should be avoided and, if possible, the mouth

should be rinsed with clean water which can then be swallowed.

Wholemeal biscuits	3 average
Buttered scones	2 average
Sliced cake	$1\frac{1}{2}$ ounces
Sandwiches	$3\frac{1}{2}$ ounces
Filled rolls	4 ounces

LUNCH

Lunch should be a comparatively small meal and seldom the main meal of the day.

If it is too bulky, it restricts breathing and is physically inconvenient for those exercising or working in a bent or crouched position. It is for this reason that a large meal is seldom consumed before an athletic event and men engaged in such occupations as sheep-shearing and coal-mining seldom have large midday meals. Apart from restrictions imposed by its volume, a large meal tends to accentuate fluctuations in heat production, particularly if the meal contains much protein, and under some conditions it may cause unnecessary sweating.

For people engaged in strenuous physical activities requiring a large number of calories, a more compact lunch can be provided by increasing the fat content. Fat confers compactness without too much bulk. Two cubic inches of fat will provide about 250 Calories whereas it will take about 10 cubic inches of a fairly compact carbohydrate to supply the same amount of energy. Hence, the provision of calories in the form of fat can make a substantial reduction in the size of a meal as well as increasing its satiety value. If the quantity of fat is excessive, however, problems of digestion and utilization may be encountered. Usually no difficulty is experienced with a meal that provides one-third its total calories as fat. For instance, for a person requiring 3,600 Calories per day, 900

of which are provided by lunch, this meal could contain over 1 ounce of fat.

For people engaged in sedentary activities requiring a small number of calories, a lunch containing substantial amounts of fat is unnecessary and could even be objectionable. It has already been pointed out (page 65) that insufficient exercise and the consumption of large amounts of fat may be factors in the causation of coronary heart disease. The fats receiving particular attention are the harder fats of animal origin. Hence, for the sedentary worker, a vegetarian type lunch is probably to be preferred. This could consist of salad sandwiches rather than ham or beef. Dried fruits and prepared nut foods, such as peanut butter, could also be used as sandwich fillings.

Lunch should seldom provide more than one-fourth the day's calories and, for most people, one-fifth would be sufficient. It could consist of a cold lunch comprising sandwiches and a beverage, or a hot lunch in which the sandwiches are replaced by a hot snack or light entrée-type dish. Soup is sometimes included but seldom adds much to the nutritional value of the meal. No matter whether it is a cold lunch, or some form of hot lunch, nutritional standards for a definite part of the day's requirements should be met.

For sedentary workers, the solid component of a normal lunch should not exceed about 9 to 12 ounces.[2] For manual workers with higher caloric requirements, it may be a little heavier, although substituting fat for carbohydrate would reduce the weight. The kinds of food consumed at lunch enable calories to be increased more readily than at breakfast, where bulky cereal foods usually form an important part of the meal. The following lunches would provide about 600, 750, and 900 Calories, respectively. These would be sufficient to meet most requirements.

[2] See reference (f).

(a)	Salad sandwich	8 ounces
	Tea or coffee with milk	1 ounce
(b)	Hamburger	8 ounces
	Fresh fruit	1 piece
	Milk	1 pint
(c)	Veal cutlet	4 ounces
	Mashed potato	2 ounces
	Bread and butter	2½ ounces
	Tea or coffee with milk	1 ounce

Tea, coffee and milk are popular lunch-time beverages, the first two being of value because of their stimulating properties and the last because of its high nutritional value. Because they serve as mild stimulants, tea and coffee are probably of greater value to sedentary workers than those engaged on physical work. During the last war, it was advocated that office workers be granted an extra allowance of tea or coffee on similar grounds to those that permitted heavy manual workers an extra allowance of foods high in calories.

In factories and offices, the length of the lunch period depends on many factors including the convenience of available eating facilities. It should be long enough to permit consumption of an adequate meal, without haste, and to enable factory and office employees to leave the work environment for a short period, and, in the case of sedentary workers, to take a little exercise. Appetite and digestion are affected by the conditions under which a meal is eaten, a meal eaten in haste or under pressure being less likely to be well digested than one eaten at leisure. Only if wash and lunch facilities are conveniently located, and there is no waiting for food, can 30 minutes be considered sufficient time for a lunch break.

It is generally recognized that the diets of women in

offices and factories are frequently poorer than those of men. Women are known to make poorer food selections probably due to their concern about gaining weight. A somewhat similar position exists in the home although for a different reason. Many housewives who are not required to prepare a midday meal for the rest of the family will not go to the trouble of doing so for themselves.

DINNER

The evening meal usually consists of dinner, sometimes followed by a light supper.

Some people, particularly in colder climates, prefer to have dinner in the middle of the day with a lighter meal in the evening. In general, this is not desirable, if work or sport is to be an afternoon activity, because of the lassitude and disinclination for activity that follows. Food consumed in the evening should be planned in conjunction with the meals consumed earlier in the day and should provide the remainder of the day's calories and nutrients. A deficiency on one day should not be carried forward to the next.

Dinner is partly a social occasion taken in a more leisurely fashion than the other meals and at a time when a little over-eating can be better tolerated. It is frequently the only meal of the day when all members of the family are together. The range of foodstuffs consumed is usually wide and varied and, in higher income groups, the meal may tend towards a formal pattern of three or more courses. Families consuming a number of courses, and hence a greater variety of foods, have a better opportunity to consume the nutrients needed to complete the day's requirements.

The components of a typical dinner that would provide about 1,200 Calories are listed hereunder. Cheese and biscuits may replace the sweet, and a side plate of salad may replace the fruit.

Soup	
Thin or thick	8 ounces
Main Course	
Meat, without bone	4 ounces
Potatoes	3 ounces
Green vegetable	3½ ounces
Yellow vegetable	3½ ounces
Gravy	1 ounce
Sweets	
Pudding with sauce (or cheese)	4 ounces
Fruit	
Fruit (or salad)	1 piece
Tea or coffee with milk or cream	1 ounce

In families where a large evening meal is provided, a problem may arise concerning any school children with homework to be done. Either this work should be done before dinner, or the children provided with a substantial snack on arriving home from school followed by a more moderate dinner. It would not be advisable to reduce the size of dinner, making supper a moderate or large meal.

Dinner should not be taken too late in the evening, but at least two or three hours before retiring. It should not be too rich nor too elaborate. Otherwise digestion is likely to be poor and the night's rest disturbed.

SUPPER

Supper is of importance because it shortens the period of the overnight fast, but, nevertheless, should be a very light meal. Light suppers have been found to promote restful sleep whereas heavy suppers increase sleep movement, the sleep of children being affected to a greater extent than that of adults.

The kind of supper that has been found most beneficial

consists of warm milk together with a light cereal supplement. These could provide about 140 Calories as follows:

Warm milk	6 ounces
Wholemeal biscuit	1

IRREGULAR MEAL PATTERNS

Meals at irregular hours may be necessary for people engaged on shift work, and others required to work at night. Nevertheless, they are undesirable on physiological grounds because they tend to upset the regular rhythm of activity and rest. They also present many practical difficulties when the other members of a family are following a normal meal pattern.[3]

As a result of day-time activities, the temperature of the body rises to a maximum late in the afternoon and then, as a result of reduced activity, falls one or two degrees to a minimum early in the morning. This rhythm is upset when people are required to perform shift or night work. A change of rhythm takes some time to establish and if a reversal of habits is not complete, or of short duration, it may be modified but not completely developed. Some people cannot readily adapt themselves to a changed rhythm even when the inversion is complete. Consequently they make poor night workers. Their appetite and desire for food is frequently reduced, they become fatigued comparatively easily, and their proneness to accidents may be increased.

When night work involves a complete inversion of day work, there should also be a complete inversion of meal pattern. That is, the same kinds of meals should be served in the same sequence, and with approximately the same intervals in between. When timing is such that suitable meals cannot be provided from home, facilities for obtaining them should be available at the place of employment. A night

[3] See H. M. Vernon, *The Health and Efficiency of Munition Workers* (Oxford University Press, 1940).

worker should not be required to leave his bed during the middle of his sleeping hours to share a regular cooked meal prepared for other members of the family, nor to be content with a light supper when his requirement is for a three-course dinner.

The nutritional requirements of night workers are the same as those of day workers, engaged on similar work, and feeding patterns should conform to the same standards.

Selected Reading

A comprehensive review of the older literature on the effects of nutrient intake on physical performance is to be found in the following article, which contains 410 references:

(a) A. Keys, 'Physical Performance in Relation to Diet', *Federation Proceedings, 2,* 164 (1943)

This was brought up to date in a more recent paper:

(b) E. Simonson, 'Influence of Nutrition on Work Performance', in *Nutrition Fronts in Public Health*, Nutrition Symposium Series No. 3 (The National Vitamin Foundation Incorporated, New York, 1951)

Information on mental efficiency and intellective performance, respectively, are to be found in two reviews dealing mostly with physical performance. The first is:

(c) R. C. Hutchinson, 'Meal Habits and their Effects on Performance', *Nutrition Abstracts and Reviews, 22,* 283 (1952)

The second deals with the principal methods used in studying performance in relation to nutrition:

(d) J. Brozek, 'Physical Performance', in *Methods for Evaluation of Nutritional Adequacy and Status* (National Academy of Sciences, Washington, 1954)

The results of research into the effects of eating large midday meals, and of long periods between meals, are to be found in two original papers:

(e) D. A. Laird, D. DeLand, H. Drexel, and K. Riemer, 'A Study of a Dietary Cause and Possible Elimination of Early Afternoon Sluggishness', *Journal of the American Dietetic Association, 11,* 411 (1936)

(f) R. C. Hutchinson, 'Effect of Gastric Contents on Mental Concentration and Production Rate', *Journal of Applied Physiology, 7,* 143 (1954)

Recent reviews on energy requirements for various kinds of physical activity, and a determination of the energy requirements of a group of soldiers, are given in the following publications:

(g) R. Passmore and J. V. G. A. Durnin, 'Human Energy Expenditure', *Physiological Reviews, 35,* 801 (1955)

(h) *Calorie Requirements*
(Report of the Second Committee on Calorie Requirements, Food and Agriculture Organization, 1957)

(i) R. C. Hutchison, 'The Caloric Requirements of a Soldier', *Activities Report, 8,* 37 (1956)

Footnotes throughout the text give references to other publications that should be consulted for more detailed information on specific points.

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